SCIENCE ABSTRACTS

Section A.—PHYSICS.

APRIL 1921.

GENERAL PHYSICS.

576. *A Torsion Balance with Vertical Movement; Apparatus and Theory.* **A. Berroth.** (Zeits. Instrumentenk. 40. pp. 210–211, Nov., 1920.)—A knowledge of the variation of gravity with height is of great value in geodesy and practical geology. The torsion-balance methods of Eötvos provide great sensitiveness. This paper is a short mathematical treatment of the possibilities of these methods. P. E. S.

577. *Standardisation of Weights; a Modified Richards' Method.* **A. J. Hopkins, J. B. Zinn,** and **H. Rogers.** (Am. Chem. Soc. J. 42. pp. 2528–2531, Dec., 1920.)—A modification is described of the method given by Richards (1900) for the standardisation of a set of weights, use being made of a box of standard weights. T. H. P.

578. *Studies with the Ionisation Gauge.* **S. Dushman** and **C. G. Found.** (Phys. Rev. 17. pp. 7–19, Jan., 1921.)—*An ionisation gauge for measuring very low pressures.*—This gauge is the result of an attempt to develop a more convenient instrument than those previously available. It is based upon the fact that the positive ionisation produced by a given stream of electrons varies with the gas pressure. By adopting a *construction* similar to that used for low-power pliotrons, erratic effects due to the charging up of the glass walls were avoided and, with a constant electron emission, a linear relation was obtained between ionisation current and pressure down to the lowest pressure actually obtained, about 10^{-3} bar. For pressures above 10^{-1} bar the *calibration* was carried out by comparison with a McLeod gauge; but for lower pressures a method was used which involves an application of Knudsen's laws of flow. *Characteristic curves* showing the effect of varying the positive voltage and the electron emission on the ionisation current are given. The *low limit of pressure* measurable with such a gauge is fixed only by the sensitivity of the galvanometer used to measure the ionisation current. With an ordinary sensitive galvanometer, pressures as low as 10^{-4} bar can readily be determined. AUTHORS.

579. *Theory of Brownian Movements.* **L. Wertenstein.** (J. de Physique et le Radium, 1. pp. 63–64, Aug., 1920.)—Perrin has shown that the mean square of the displacement of a particle in a given direction is proportional to the time in the case of intervals large enough to be comparable with the time T which elapses before the particle loses completely its initial speed. When the interval considered is small compared with T, the mean displacement must be proportional to the product of the mean speed by the time, and therefore the mean square to the square of the time. A general solution is now easily obtainable. Taking Langevin's equation, $m\ddot{x} + \mu x = \mathrm{X}$, where m is the mass of the particle and μ is the coefficient of friction, and noting that $\overline{\mathrm{X}_x} = 0$, $\overline{\dot{x}^2} = k\mathrm{T}/m$, and that $\overline{x^2} = 0$ for $t = 0$, the general solution is found to be $x^2 = 2k\mathrm{T}t/\mu - \mu/m\,.\,(1 - e^{-\mu t/m})$. For large intervals this differs from the usual formula only by m/μ, which is negligible for intervals of practical importance, being of the order of 10^{-6} sec. for the largest particles concerned in the Brownian movements. When t is small, terms of order above the second may be neglected, so that $\overline{x^2} = k\mathrm{T}t^2/m = \overline{\dot{x}^2}t^2$. Thus, theoretically, the mean speeds of translation should be obtainable from observations of sufficiently small intervals. These, however, would not appear to be practically possible, so that the solution here arrived at must be regarded as of theoretical interest only. [Errata: *ibid.*, Oct., 1920.] G. W. DE T.

580. *New Aerological Apparatus; a Light-weight Meteorograph.* **S. P. Fergusson.** (Monthly Weather Rev. 48. pp. 317–322, June, 1920.)—The height to which a balloon will rise depends primarily upon the ratio of the lift to the weight carried. The large rubber balloons of either the Assmann or Paturel type required to lift the meteorographs heretofore employed in aerological investigations are costly, and doubtless this circumstance has limited the use of *ballons sondes.* An investigation of the methods and requirements of aerology has led to the production of a new meteorograph of very simple construction, important parts of which can be made economically in quantity. The scales, particularly that of the pressure-element, are wider than those of other instruments of the kind, the various operations of preparation and reading the records have been simplified, and the weight is less than one-third that of the next lightest instrument that has been used with *ballons sondes.*

One or two small pilot balloons, costing but one-tenth as much as the Assmann balloons, can lift the new meteorograph, and since the pilot balloons are of better quality the heights attained should be greater than those now possible with the larger balloons and heavy equipment.

An experimental recording meteorograph and a temperature-element without pivots, suitable for use with the Goddard rocket or in other apparatus are described in order to suggest the direction of further study and experiment. AUTHOR.

581. *Employment of the Aerometer in the Laboratory.* **W. Block.** (Zeits. techn. Physik, 1. 7. pp. 125–129, 1920.)—The aerometer, which is an instrument admitting of the exact calculation of its dimensions, is capable of yielding results of considerably greater accuracy than is usually supposed. The method of calculation is indicated, allowance being made for the capillarity of the liquid. Theoretically the sensitiveness and accuracy of an aerometer are unlimited, but in practice a sensitiveness of 1×10^{-5} is surpassed only with great trouble. The questions of wetting of the stem, temperature, capillarity, testing, and method of reading are discussed. T. H. P.

582. *On the Notion of Simplicity in the Methods of Physics and the Exact Sciences.* **H. Dingler.** (Zeits. f. Physik, 3. 6. pp. 425–436, 1920.)—In his important treatise dealing with so-called absolute motion, space, and time, H. v. Seeliger emphasises in an especially clear manner the simplicity of the so-called Euclidean geometry, which quality must be regarded as an essential. This problem of simplicity does not hitherto appear to have been investigated, and forms the subject matter of the present paper. The notion and demand for simplicity play a most important rôle in the consideration of the exact sciences, and the work of Mach and Avenarius (on the so-called economy principle), Ostwald, Petzold, and others is referred to. Section I of the paper deals with general exceptions and contains an attempt at an exact logical definition of simplest in a definite sense—namely: In a group of logical formulations the term simplest is given to those which require the smallest number of positive independent elementary individual determinations for that particular group. The problem then arises as to whether the definition is always capable of expression. The present paper deals only with special groups of cases which admit of solution, and Section II is devoted to such soluble cases. Example: Among the possibilities of the effects due to an active point in an environment, the simplest case is where the activity is equal on all sides. Section III considers special cases. Example: Of all the plane curves $y = f(x)$, the simplest curve is $y = ax + b$. In this section space and time are discussed, following which comes an investigation of the simplest standpoint for the Newtonian law. H. H. Ho.

583. *Evaporation of Small Mercury Spheres: Divergencies between Theory and Experiment.* **E. Rie.** (Ann. d. Physik, 63. 8. pp. 759–765, Dec. 10, 1920.)—Mercury spheres of about 10^{-5} cm. radius are used by various observers, Ehrenhaft, Konstantinowsky, Schidlof, and others in work on electrons. The diffusion theory of Stefan would indicate a rate of evaporation for these spheres much greater than those found by these observers. P. E. S.

584. *New Methods in Interior Ballistics.* **A. G. Webster.** (Nat. Acad. Sci., Proc. 6. pp. 648–659, Nov., 1920.)—If z is the fraction of powder burnt and x the travel of the shot, it is required to find x in terms of z. A differential equation of the second order and third degree in dx/dz is obtained, which is complicated but exact. The experimental tests have been partially carried out, but the data for a complete report are not yet available. E. H. B.

585. *Measurement of very Short Time Intervals by the Condenser-charging Method.* **J. J. Dowling** and **D. Donnelly.** (Roy. Dublin Soc., Proc. 16. pp. 165–170, Feb., 1921.)—Reference is made to previous similar work [see Abs. 792 and 1120 (1920)]. The arrangement of apparatus employed is described and sketched diagrammatically. The main practical difficulty lies in the means employed in causing the condenser to commence and cease charging at the beginning and termination, respectively, of the time interval to be measured. To overcome this, a bullet is caused to break successively two fine copper wires, in which practically the same currents are passing. The bullet velocity is determined by the angular displacement of successive perforations in revolving paper discs. The results of 12 consecutive readings are tabulated and show errors of from 0·4 % to 5·4 %, the time interval ranging from 72 to 81·6 micro-seconds. In another arrangement, the bullet is caused to break the circuits by lifting the wires from two metallic supports. By this means, intervals of about 40 micro-seconds are measured with about the same accuracy as was obtained for the larger intervals mentioned above. A. B. C. L.

586. *The Physiology of Measurements.* **H. Schulz.** (Zeits. techn. Physik, 1. 6. pp. 116–121, and 1. 7. pp. 129–137, 1920.)—In these two papers there is a careful, partly mathematical, treatment of the effect of the eye on the accuracy of measurements. The cases considered are length measurements, photometric comparisons, interference measurements, and microscopic measurement. The limit of accuracy attainable depends even more, in some cases, on the nature of the eye than on the limitations of the apparatus employed.

The limit of accuracy attainable in interference work is put at 0·05 μ, and in microscopic measurement at 0·6 μ. P. E. S.

587. *New Method of Joining Glass.* **C. O. Fairchild.** (Optical Soc. of America, J. 4. pp. 496–503, Nov., 1920.)—The method consists in maintaining the glass at a temperature sufficiently high to avoid cracking, at the same time applying heat locally, the temperature of the main body of the glass being such that undue distortion will not occur. The body temperature necessary is always near the annealing temperature, and this depends primarily upon the kind of glass, but is also dependent to some extent upon the dimensions of the article. An electric furnace was used for heating the glass to the proper temperature during local fusion of a joint. The furnace has a mica window at the top, and a side hole for introducing a blowpipe. Through the centre of the bottom passes the stem of a small table on which glass objects can be placed and rotated about a vertical axis. Illustrations are given of various articles made by this method, and include: Glass rings with plane covers; hollow prism; optical pyrometer lamp; absorption cells, etc. Examination showed that the plane surfaces had, in the majority of cases, suffered hardly any distortion. [(See Abs. 1437 (1920).] A. W.

588. *On the Free Oscillations of Spheroids.* **R. N. Ghosh.** (Phys. Rev. 16. pp. 477–480, Nov., 1920.)—*Oscillations of liquid drops*, assuming the potential energy for any momentary form to be that due to capillarity only. Rayleigh's method of energy is applied so as to yield a formula for the frequency of oscillation for cases where the momentary surface differs from that of equilibrium by a spherical harmonic deviation of arbitrary order and rank. AUTHOR.

589. *Resistance of Fluids and Vortex Motion.* **J. M. Burgers.** (K. Akad. Amsterdam, Proc. 23. 5. pp. 774–782, 1921.)—The relationships existing between the resistance suffered by a body moving in a viscous fluid, and the properties of the vortices generated by its motion are considered mathematically, and general formulæ derived. The resistance to motion experienced by the body is equated to the sum of the impulses required to produce the successive vortex layers generated at its surface. A. B. C. L.

V.
19

590. *Stability of Steady Motion of Viscous Liquids.* **K. Tamaki** and **W. J. Harrison.** (Cambridge Phil. Soc., Trans. 22. pp. 425–437, Oct., 1920.)—In Mallock's experiments [Roy. Soc. Proc. 45. p. 126, 1888; see also Abs. 392 (1915)] on the motion of a viscous fluid contained between two concentric cylinders, one fixed and one rotating, the motion was always found to be turbulent only when the inner cylinder was rotated. The problem is here investigated analytically without revealing any reason for this distinction. But the low limits obtained for the critical angular velocity afford evidence of a certain inherent instability, and it is, accordingly, inferred from the experimental evidence, that the special types of disturbance corresponding to these limits are likely to be set up when the inner cylinder rotates, but not when the outer one is rotating. Lamb has stated [Hydrodynamics, 4th Edition, p. 655], without, however, any formal proof, that the motion would necessarily be unstable in the former case, since other distributions of velocity than that in the accepted state of steady motion are possible which have less kinetic energy for the same angular momentum. One of the authors has been in communication with Lamb on the subject, and here investigates the question analytically, and it is found that the acceptance of Lamb's criterion would involve results which are negatived by the experimental evidence. An investigation into the effect of proceeding to a higher approximation on the usual stability criterion appears to resolve the discrepancy between the conclusion arrived at by Reynolds [Sci. Papers, vol. II., p. 572] that a certain degree of viscosity is necessary for stability, and that of Rayleigh, that certain steady motions of a non-viscous fluid are stable. Rayleigh's conclusion has been verified by G. I. Taylor [Abs. 536 (1915)] by means of entirely different considerations.

G. W. de T.

591. *Relativity Theory.* **C. Willigens.** (Archives des Sciences, 2. pp. 289–300, July–Aug., 1920.)—The author develops consequences of the postulates adopted by E. Guillaume in what the latter describes as "Relativity Theory on the Basis of Universal Time" [see Abs. 382 (1919) and 1125 and 1247 (1920)], which he shows to be irreconcilable with the scheme expressed in the Minkowski time-space. The author's deduction from this is that Minkowski has blundered. G. W. de T.

592. *Relativity Difficulties and Suggestions.* **J. R. Partington.** (Nature, 106. pp. 113–114, Sept. 23, 1920.)—Suppose a cube of unit volume, of rigid material impervious to heat, to contain a gas of temperature T as measured by an observer attached to the box. The volume of the cube as measured by an observer having a uniform velocity v in the direction of an edge, will, according to relativity theory, be $1/\sqrt{(1 - v^2/c^2)}$, and the temperature $T\sqrt{(1 - v^2/c^2)}^{\gamma-1}$. The latter, depending on γ, the ratio of specific heats, will therefore depend on the structure of each of a definite number of molecules of gas contained in the cube. If the gas be $2HI \rightleftharpoons H_2 + I$, the extent of dissociation will depend only on the temperature and not on the volume, and can be measured by the change in intensity of a beam of light traversing the box in a direction perpendicular to its velocity, and received by the second observer. The consideration of the case of the cube at rest and the second observer in motion then appears to involve the transformation of the statistical equations for the energy and entropy of the gas in terms of the position and momentum coordinates of the molecules. The author asks:—What would be the objection to defining simultaneity in the case of two observers starting from and ultimately returning to a given position either by means of a chemical reaction taking place at a measurable rate in a given position, or by radio-active change, the observers taking with them from the common starting point equal quantities of solution or equal weights of radium, stopping the former reaction at the observed instants of a phenomenon observed by both, or measuring their times by counting the α-particles emitted, and defining the observations as simultaneous when the changes were equal? He also calls attention to Bucherer's work [Abs. 1248 (1920)], showing that the displacement of spectrum lines may be obtained from thermodynamic considerations without relativity assumptions. He also suggests that the solar deflection of light rays may yet be shown to depend on ether condensation—a hypothesis suggested by Newton [Boyle's Works, edited by Birch, vol. I., 1744].

G. W. DE T.

593. *Perrot's Experiment on the Efflux of Water from an Orifice.* **J. Rey.** (Comptes Rendus, 171. pp. 343–345, Aug. 9, 1920.)—Perrot claimed to have shown experimentally [Comptes Rendus, 49. p. 637, 1859] that when water was allowed to flow out through an orifice at the centre of the base of a vertical cylinder, the trajectories of the surface molecules were sensibly affected by the earth's rotation, and the results claimed by him are very generally reproduced in modern treatises on hydraulics, together with the important consequences respecting river erosion which Babinet deduced from them [Comptes Rendus, 49. p. 638, 1859], and maintained, in spite of the destructive criticism of J. Bertrand [Comptes Rendus, 49. p. 658, 1859]. F. Laroque [Comptes Rendus, 51. p. 758, 1860] repeated Perrot's experiments, and came to the conclusion that the gyratory movements observed by him are quite unconnected with the earth's rotation, and many physical geographers have shown the incorrectness of Babinet's conclusions. The author has, at the suggestion of C. Camichel, repeated Perrot's experiment with a cylinder containing about 25 kg. of water and also with a vessel built up of iron plates bolted together at right angles, without any centre of symmetry, and containing about 4 "tonnes" of water. The results confirmed Laroque's conclusions. In the first experiment no gyratory motions could be detected. In the second, such movements were observed when the depth of water had fallen below 15 cm. But they were extremely irregular, and apparently due simply to the intentionally devised irregularities of the base and sides of the vessel. A simple calculation showed that the horizontal component of force arising from the earth's rotation, at lat. 45°, is about one hundred-thousandth of the weight at rates of flow of the order of a metre per sec., so that the effect of the earth's rotation would be completely masked by internal fluid friction. G. W. DE T.

594. *An Electromagnetic Theory of Gravitation.* **H. A. Wilson.** (Phys. Rev. 17. pp. 54–59, Jan., 1921.)—An electric system in a medium whose specific inductive capacity k varies from point to point tends to move in the direction of increasing k. It is suggested that if we *assume the specific inductive capacity of the ether to vary near matter*, gravitation may be explained as a result of this tendency. In a medium in which at a distance r from a mass m, $k = 1 + m/r$, it is shown that a rigid electrostatic system would be acted on by a force directed toward m and equal to mm'/r^2, where m' is the electromagnetic mass of the system. But in order to *explain the observed deflection of light by the sun* we must have $k = 1 + 2m/r$; and this will not give the force mm'/r^2 unless the system contracts in the ratio of $1 : 1 - m/r$. A physical explanation of this assumed contraction is suggested. If the system with the mass m' is also supposed to modify k, it is necessary to take into account the energy changes in m and in the ether. The *effect of gravitation on the frequency of the light emitted by an atom*, which was predicted by Einstein, can be easily deduced from the present theory. AUTHOR.

595. *Electricity and Gravitation.* **H. Bateman.** (Phys. Rev. 17. pp. 64–69, Jan., 1921.)—*Electric Doublet Theory of Gravitation.*—It is suggested that gravitation may be an effect arising from fluctuations of the electric charges associated with the electrons and positive nuclei of atoms. It is assumed (1) that the ether contains an enormous number of electric doublets moving in all directions with the speed of light; (2) that each charged particle is continually both absorbing and emitting doublets at a rate proportional to its mass; and (3) that during the absorption and emission of each doublet the charge on the particle fluctuates. If these fluctuations exist, it is shown that the mean value of the force exerted by one charged particle on another includes, in addition to the ordinary electrostatic force, an attraction proportional to the product of the masses.

Electric Doublet Theory of Radiation.—If we suppose that the doublets emitted by a particle possess available energy only when the energy of the particle changes, and that the effect of changing the energy is to produce periodic gaps in the emission of doublets with a frequency proportional to the amount of energy lost, we have a theory of radiation which is said to be compatible with the theories of Bohr, Planck, and Einstein. AUTHOR.

596. *Gravitation as an Electrodynamic Phenomenon.* **E. Wiechert.** (Ann. d. Physik, 63. 4. pp. 301–381, Oct. 19, 1920.)—In a previous paper [see Abs. 13 (1917)] the author has considered the problem as to whether methods exist for the explanation of the perihelion motion of Mercury based on current mechanics, and without recourse to the revolutionary procedure of the relativity theory. He now returns to the problem, since in the above paper no account had been taken of the deflection of light rays in the gravitational field, and finds gravitation to be an electrodynamic phenomenon, which is inexplicable without recourse to the conception of a universal ether. Section 1 discusses the relativity standpoint in general terms; Section 2 deals with the perihelion motion of Mercury; Section 3 contains an attempt to explain the perihelion motion of Mercury in the light of Newtonian mechanics; Section 4 deals with earlier attempts to explain the perihelion motion as a deduction from Newtonian laws; Section 5 discusses the observations of light deflection in the gravitational field; Section 6 considers observation results with respect to the displacement of spectral lines in the gravitational field; Section 7 discusses an electrodynamic theory of gravitation on the assumption of relative isotropy in the field; Section 8 compares this theory of gravitation with experience; Section 9 discusses an electromagnetic theory of gravitation on the assumption of relative anisotropy of the field; Section 10 considers the basis of Einstein's theory of gravitation; Section 11 deals with relationships between Einstein's theory and that developed in the present paper; while Section 12 discusses ether and matter. As a basis for the electrodynamic theory, not only the ether conception and the assumption of the Lorentz deformation are utilised, but also the further hypothesis that the cause of gravitation depends on a change in the nature of the ether from place to place, as shown by diversity of the light velocity, and in the electrification of the smallest parts of matter. The development of these ideas has been rendered possible by the use of the Lagrangian function which Abraham introduced for the study of electronic dynamics. In the author's theory, gravitation appears to be due to the interaction of two factors, the one being analogous to the force which, in a dielectric liquid of variable dielectric constant at different points, drives an electrified body from places of lower to those of higher dielectric constant, while the other is analogous to the force which, in a liquid possessing varying pressures at different points, drives a body therein from places of higher to those of lower pressure. The present theory has been confined to stationary fields. The assertions of Einstein's theory are shown, however, to be deducible on the present theory, but greater accuracy in the astronomical data is held to be desirable. The conception of a universal ether is opined to be of fundamental importance. H. H. Ho.

597. *Bohr's Atomic Model and the Theory of Relativity.* **K. Försterling.** (Zeits. f. Physik, 3. 5. pp. 404–407, 1920.)—The quantum and relativity theories appear sometimes to be opposed, possibly because the quantum theory is incompatible with the Maxwell equations. Since, however, the principle of relativity possesses general validity, the same must be true of the quantum theory. In the present paper it is shown that from the Bohr frequency condition together with the hypothesis of the inertia and gravitation of energy, *i.e.*, from very general assumptions excluding intimate details of the separate theories, the displacements of the spectral lines may be deduced, this being still lacking on the special and general theory of relativity. Sections 1 and 2 discuss the special and general theories of relativity, respectively, from the above quantum standpoint, and agreement appears to be established. H. H. Ho.

598. *Electrostatic Potential of Spacial Atomic Models.* **T. Rella.** (Zeits. f. Physik, 3. 3. pp. 157–168, 1920.)—In his work on cubic atomic models, Born has calculated to a first approximation the reciprocal potentials of two cubes on each other, while Smekal has generalised the Born result for cubes not orientated parallel. Thirring has calculated the reciprocal potentials of two atomic models consisting of four crossed electronic ring orbits of equal radius and centre—in which the positive nuclear charge is located—whose surface normals are arranged like the 4-space diagonals of a cube. The present author now investigates the following problems:—In an atomic model, which possesses the symmetry of the tetrahedron or the cube, the positive nuclear charge should be located at the centre of symmetry, while the negative electrons should either be arranged in a point system of given symmetry about the nucleus, or circulate in rings of specified character. The atomic model may be neutral or otherwise. What will be the potential of such an atomic model at any external point, and the reciprocal potentials of two such atomic models? Section 1 considers the tetrahedron and cubic groups; Section 2, the potential at an external point of an atomic model with static electrons; Section 3, the reciprocal potentials of two atomic models with static electrons in parallel orientation; Section 4, the transition to atomic models with circulating electrons; Section 5, the case of an atomic model in the absence of parallel orientation. The paper is mathematical throughout. H. H. Ho.

599. *Cubic Atoms, the Periodic System, and Molecule Formation.* **A. Landé.** (Zeits. f. Physik, 2. 4. pp. 380–404, 1920. Phys. Zeits. 21. pp. 626–628, Nov. 1 and 15, 1920.)—Recently the evidence against the conception of plane electronic ring systems has considerably increased, while that for a spacial arrangement of the electrons in the atom has accumulated. Reference is made to previous work on the compressibility of regular crystals as an electrostatic effect between cubic shells [see Abs. 528 (1919)], a result which may be deduced from the symmetry properties of these crystals [see Abs. 1533 (1920)]. From the chemical standpoint Lewis has emphasised the great part which the stable cubic configuration of 8 electrons plays in the Kossel conception of the periodic system, an idea which Langmuir has extended for the systematic study of chemical compounds. The problem now arises as to whether the cubic hypothesis may be combined with the Bohr conception that electrons move in definite quanta orbits about the positive atomic nucleus. The author first seeks a solution by reducing the 8-body problem to a single one [see Abs. 868 (1919)]. Section 1 deals with polyhedral orbits of regular symmetry (4, 8, 12, 24, 48 electrons); Section 2 with polyhedral orbits of lower symmetry (3, 4, 6 electrons); Section 3 with ellipse union in the polyhedral combination; Section 4 with cube shell arrangement in the atomic interior; Section 5 with the atomic exterior (Na, Ne, F, O); Section 6 with the arrangement of H^+ nuclei in cube ions; and Section 7 with ionisation tension for hydrofluoric acid and water. *Conclusions.*—The conclusions drawn are summarised by the author as follows:—(1) For 4 and 8 electrons, spacial orbits of cubic symmetry may be calculated; (2) For any other electronic numbers spacial orbits of lower symmetry are given; (3) The single electrons describe approximately circular or Kepler elliptic orbits; (4) Elliptic orbits are pursued when there are no external (valency) electrons and no internal (double-shell) electrons to prevent the formation of such eccentric orbits, otherwise circular orbits are developed; (5) The cubic orbits proposed by Madelung and the author are appreciably more stable than a plane ring of 8 electrons; (6) If that atomic state be regarded as the most stable which possesses the smallest energy content, then the atomic interior must consist of arrangements of cubic shells of 8 electrons, so that mutual disturbances can play no part; (7) With ionised alkalies, the cube is more stable than any other configuration. The radius of the Na^+ ion is in agreement with the crystal-lattice data; (8) With the noble gases, the cubic shell is appreciably more stable than every other charged or uncharged configuration. The ionisation tension of neon is found to be as great as would be expected from measurements with argon; (9) With the halogens, other configurations begin to compete with the ionic cube. By spacial models the Born electronic affinity of F-atoms can be qualitatively derived from universal constants. The ionic radius is in agreement with the lattice dimensions and chemical data; (10) In the oxygen group the doubly-charged negative ion probably consists of a cubic shell of 4 electrons.

The ionic radius is in agreement with chemical data; (11) The exponent $n = -9$ in the potential of the regular crystal lattice does not denote Born's cube alone, but a cube with like provision for both kinds of ion; (12) H^+ nuclei find equilibrium with the dynamic cube orbits when they lie near the cube corners; (13) The ionising energy and the nuclear distance of HF may be approximately calculated by means of universal constants. The F'-ion, according to 4 and 9 above, has a cube shell from the elliptic orbits of 8 electrons; (14) The ionisation energy and moment of inertia of H_2O have been approximately calculated by means of universal constants. The O''-ion, according to 4 and 10, has a cube shell from the circular orbits of 4 electrons. H. H. Ho.

600. *Direct Determination of the Free-Path Length of Neutral Silver Atoms.* **M. Born** and **[Miss] E. Bormann.** (Phys. Zeits. 21. pp. 578–581; Disc., 582, Nov. 1 and 15, 1920. Paper read before the 86. Naturforscherversamml., Nauheim, Sept., 1920.)—Stern having shown [*ibid.*, p. 582] that the particles emitted by fused silver in a high vacuum are silver atoms, the authors determine the free-path length of the atoms in the following way: A quartz tube, 3 cm. in diameter, has a small cavity at the bottom to receive the grains of silver; this part is surrounded by an electric furnace, but the tube above it is cooled by CO_2 snow. In the tube 4 horizontal brass discs, each pierced in the centre by a hole 5 mm. in diameter, are mounted 1 cm. apart. Over each hole is placed a glass quadrant; the successive quadrants are so staggered by 90° that they would, if in the same horizontal plane, close the central vertical channel. Experiments are made at the highest vacuum obtainable (pressure p_0) and at pressures p of about 5×10^{-3} cm. At the end of an experiment the glass quadrants are taken out and placed together so as to make up a circular glass disc, with a central black circle of deposited silver particles. It is found that, at pressure p, the four silver spots are distinctly graduated in intensity, the first (nearest the silver grains) being the darkest and the fourth, most remote, the faintest; at p_0 the graduation is much less marked. By covering, in another series of experiments, the holes with complete circular glass discs, comparison silver mirrors are obtained with exposures of 1, 2, 4, 8 seconds; with the aid of these and a Hartmann stellar photometer the thickness of the silver deposits on the quadrants is estimated. If λ be the mean free path, $p\lambda$ should be constant; the average value found is $p\lambda = 0{\cdot}01$ in fair agreement with Maxwell's formula. H. B.

601. *The Size of Ions and the Lattice Energy of Alkali Halides.* **K. Fajans** and **K. F. Herzfeld.** (Zeits. f. Physik, 2. 4. pp. 309–331, 1920.)—In the formulæ of Born and Landé [Abs. 300 (1919)] the repulsion-potential between consecutive rings of electrons depends on r^n, where r is the distance between adjacent ions. It was first assumed that $n = 5$, later 9; but the n did not appear to be quite the same for the various alkali halides. This variability would be in accord with Born's hypothesis of cubic ion-models, in which the electrons of the outer shells occupy the corners of cubes, the forces between which change with the mutual positions of the cubes. The formula for the lattice energy contains terms involving the 5th and 7th power when kation and anion are not of the same size. The ionic radii deduced for Na, K, Rb are 0·517, 0·794, 0·914, and for F, Cl, Br, I, 0·75, 0·953, 1·021, 1·22, all in 10^{-8} cm.

The calculated distances between the atoms are for NaF, NaCl, NaBr, NaI, 2·34, 2·817, 2·980, 3·231, in very close agreement with observations. The distance between two adjacent ion-cubes of NaCl, so grouped that their cubic faces are parallel, would then be 1·968 Å.U, *i.e.* more than twice half the sum of the sides of the two cubes. It follows also from the compressibilities of these salts that the *n* of Na must be smaller than that of K. H. B.

602. *The Size of Ions and the Lattice Energy of Alkali Halides for Model Atoms with Cubic Orbits.* **H. Schwendenwein.** (Zeits. f. Physik, 4. 1. pp. 73–88, 1921.)—Fajans and Herzfeld [see preceding Abs.] have calculated the lattice energy of alkali halides on the basis of models in which the 8 valency electrons rest at the corners of the cube. Applying the more general formula of Rella [Abs. No. 598 (1921)] the calculations are made by the author, both for the model mentioned and for the cubic-ring model of Landé [Abs. 1371 (1920)]. In the latter, the 8 electrons lie on a spherical surface, each electron moving in an octant about a diagonal of the inscribed cube. When the orbits become large, they are deformed by the repulsion of neighbouring electrons, finally forming spherical triangles connected at their corners. The radii of the ions deduced for Na, K, Rb, Cs and F, Cl, Br, I, differ from those of Landé. The lattice energies, derived from these radii, give for the various halides values, the differences between which are in agreement with the figures deduced from the heats of solution; the electro-affinities of the halogen atoms are in better agreement than those obtained by the original formula of Born, but the compressibility of the crystals comes out too large. On the whole the calculations of Fajans and Herzfeld are confirmed. H. B.

603. *Notes on Excited Atoms.* **J. Franck** and **W. Grotrian.** (Zeits. f. Physik, 4. 1. pp. 89–99, 1921.)—When an electron is raised to an orbit of higher quanta, a modification of the atom is formed; the properties of this modification can generally not be studied, because the life-period is too short, 10^{-8} sec. At the end of this period the energy is re-emitted in fluorescence. In the case of helium [see Abs. 251, 1279 and 1492 (1920)] this period is unusually long, probably because the passage from the fundamental orbit to the adjacent is there not subject to the selection principle of radiation, the energy being derived from collisions. In that case a modification of helium is formed which resembles hydrogen; according to Lenz [Abs. 574 (1920)] the band spectrum of helium is due to the formation of He-molecules from excited He-atoms. The collision must be between two excited He-atoms. Many phenomena are considered from this point of view, especially the fluorescence of mercury vapour observed by Phillips [Abs. 1827 (1913)]. In repeating these experiments the authors find that the vanishing of the fluorescence in the U-tube, as we recede from the mercury level and the vapours immediately above it, is less rapid when the partial vapour pressure is kept more constant. The Hg vapour density decreases rapidly, of course; when, however, gases (air, nitrogen, argon, helium-neon) are added to the vapour, the conditions for the probability of collisions are fairly the same throughout the tube, and the fluorescence was more pronounced and general. The nature of the gas added made very little difference, except that the denser gases seemed more effective than lighter gases. The authors speak generally of "excited," originally monatomic gases; the activation of molecules of nitrogen, oxygen, etc., may be of a different character. H. B.

604. *Crystal Structure of Calcium.* **A. W. Hull.** (Phys. Rev. 17. pp. 42–44, Jan., 1921.)—The X-ray pattern obtained with powdered calcium shows that the atoms are arranged in a face-centred cubic lattice. The side of the elementary cuve is 5·56 Å. The Ca atoms in Ca have therefore the same arrangement as in CaO and CaF_2; but in the fluoride and oxide the atoms are respectively 2 % and 14 % closer together than without the fluorine and oxygen. AUTHOR.

605. *Variation of Nocturnal Radiation on Calm Nights.* **A. Boutaric.** (Comptes Rendus, 171. pp. 1165–1167, Dec. 6, 1920.)—Contrary to certain isolated observations by Lo Surdo at Naples and Exner on the Sonnblick, observations by the author at Montpellier in 1913–14, and again on the Pic-du-Midi in 1919, on calm clear nights, show that the intensity (r) of nocturnal radiation generally reaches a maximum soon after sunset and then decreases slowly and regularly. Inserting, however, observed values of the temperature and vapour pressure in the formula $r = n\sigma\theta_0^4 F(f_0)$ previously proposed [see Abs. 1375 (1920)], the result is a small increase throughout the night. This is supposed to be due to the fact that the formula, which was based mainly on observations soon after sunset, is not sufficiently general, and that the magnitude of the inversion of temperature which progressively forms at the surface during the night must be taken into account. However, in the general case the formula gives approximately correct results. M. A. G.

606. *Relationship between Pressure and Temperature at the same Level in the Free Atmosphere.* **E. H. Chapman.** (Roy. Soc., Proc. 98. pp. 235–248, Dec. 3, 1920.)—W. H. Dines has published correlation coefficients between pressure and temperature at the same level in the free atmosphere [see Abs. 33 (1920)]. For the layers between 3 km. and 8 km. the coefficients range from 0·72 to 0·91. The present author points out that the numerical value of a correlation coefficient is lowered by observational errors so that the relationship between temperature and pressure at the levels mentioned may be even closer than Dines' figures suggest. A method of correcting the correlation coefficients for errors of observation is developed, based on the assumption that the max. possible error of a temperature reading is k times the true reading, and of a pressure reading, l times the true reading. The true correlation coefficient is expressed in terms of k, l, and the observed correlation coefficient. From W. H. Dines' value of the probable error of a recorded temperature, namely 1 deg. C., it is deduced that $k = 0{\cdot}02$ approximately. Assuming the same value for l, a table of corrected coefficients is given, for the four trimesters Jan.–March, etc., and for heights 2, 4, 6, 8, and 10 km. For the trimester April–June the corrected coefficient at 4 km. is 0·997 and at 6 km. 0·994, while for the trimester Jan.–March at 8 km. it is 0·974. Nowhere between 4 and 8 km. does it fall below 0·84. A further inquiry is then made into the possible values of k and l. A theory is developed by which, when the range of variation of the height deduced from the temperature-pressure record is known, possible pairs of values can be assigned to k and l. Blair has observed registering balloons by two theodolites and obtained the heights by triangulation as well as from the temperature-pressure records, and his results give the range of variation of height due to observational errors in temperature and pressure. Utilising his data, possible pairs of values of h and l are deduced together with the corresponding factors for converting the observed into true correlation coefficients. It is evident from the results that there is a distinct possibility of errors of observation in temperature having a more marked effect than errors of observation in pressure in increasing the observed correlation coefficients. A very reasonable pair of values is found to be $h = 0{\cdot}03$, $l = 0{\cdot}01$, and, assuming these, a second table of corrected coefficients is given showing even higher values than the first, those for the trimester April–June at 4 and 6 km. being actually unity, as is also that at 8 km. for the trimester Jan.–March, while from 3 to 8 km. throughout the year the coefficients exceed 0·84. Thus for certain months there is direct proportionality between temperature and pressure at the levels mentioned, and during the rest of the year no great departure from it. M. A. G.

607. *The Spectrum and the Theory of the Green Ray.* **A. Danjon** and **G. Rougier.** (Comptes Rendus, 171. pp. 814–817, Oct. 20, 1920.)—Telescopic observations and photographs of the spectra of the upper and lower limbs and the central portion of the sun, when near the horizon, support the theory that the phenomenon which appears to the "naked eye" as the "green ray" is due solely to normal dispersion of the sun's rays by the earth's atmosphere. Indeed, the sun when near the horizon appears as a red and green disc superposed, but with the green disc displaced upwards. The absence of the other colours is due to absorption. An objection, raised by Julius, to the normal dispersion theory, that it gives theoretically a duration of the phenomenon far less than that actually observed, is thought to be due to the refractive index taken as a basis of calculation not being in accord with actual conditions, account not being taken of the considerable fluctuations along the path of a ray, to which this index is subject: fluctuations which may not be the same for rays of different colours issuing from the same point of the sun and arriving at the eye, since these rays follow different paths. M. A. G.

608. *Some Characteristics of the Callendar Pyrheliometer.* **E. R. Miller.** (Monthly Weather Rev. 48. pp. 344–347, June, 1920.)—Theory of the Callendar automatic pyrheliometer is given. The indications of the Callendar pyrheliometer differ from the calculated intensities of radiation upon a horizontal surface on account of (1) greater sensitiveness for low intensity than for high; (2) selective absorption of short-wave radiation by platinum compensating grids; (3) internal reflection of light from glass cover to grids; (4) selective absorption by cover glass of ultra-violet and infra-red radiation from sun, and total absorption of radiation from grids; (5) grid surfaces not geometrical planes; (6) lag of registration behind radiation. AUTHOR.

609. *Measurements of Solar Radiation at Madison, Wis., with the Callendar Pyrheliometer.* **E. R. Miller.** (Monthly Weather Rev. 48. pp. 338–343, June, 1920.)—Results of observations extending over nine years are summarised, and data of related phenomena of duration of bright sunshine and of cloudiness are given. A midsummer depression in the annual march of midday normal intensity is ascribed to a maximum of haze at that time, due in turn to the increased evaporation of water and stronger convection. Spring and autumn depressions in the annual march of sun and sky radiation upon a horizontal surface are explained as arising from the double maximum in the annual march of frequency of "Colorado lows." The suggestion is offered that this double maximum is produced by the most efficient co-operation at intermediate seasons of the stationary barometric depression in Northern Mexico and the eastward drift of the atmosphere, the annual oscillations of which are in opposite phases. AUTHOR.

610. *Daytime Wind Turbulence in a Mountain Valley.* **B. M. Varney.** (Monthly Weather Rev. 48. pp. 336-337, June, 1920.)—An unusual example of wind turbulence in the daytime air stream in mountain valleys is found near Yosemite Valley, California. The stream as it flows east up the valley in the afternoon divides through two branch canyons, the current in the south-easterly branch turning sharply round a steep mountain spur. This spur and the configuration of the canyon walls sets up a rotation of air in the lee of the cliffs about an inclined axis, the lower end of which is at the spur, the upper end about a mile away to the east, the general trend being parallel to the side of the canyon. The path of an air particle near the periphery of this roll was found, by observations on the drift of tissue papers, to be that of a great spiral, the diameter of which seems to vary from nothing at the spur to perhaps 2000 ft. at the east end. Observed variations in the form of the spiral are due to changes in the local winds under the influence of topography. AUTHOR.

611. *A General Theory of Haloes.* **C. S. Hastings.** (Monthly Weather Rev. 48. pp. 322–330, June, 1920.)—The general theory of haloes developed in this paper rests on the assumptions that two kinds of simple ice-crystals—elongated hexagonal rods and hexagonal plates—are occasionally present in a tolerably transparent atmosphere; moreover, that these crystals subsiding in quiescent air would necessarily fall into four groups.

The first portion of the paper establishes the validity of the assumptions by reference to well-recorded observations.

The second portion is devoted to a development of the consequences from the presence of each of these groups for various altitudes of the sun. It is there shown that all the authenticated features of complex haloes are naturally explained (excepting certain rare multiple concentric circles) as inevitable consequences of the hypotheses. In addition, this portion gives a new means of classifying the various phenomena, showing unsuspected relationships as well as essential diversity in certain other cases where common origin was formerly assured. AUTHOR.

612. *Diurnal Variation of Temperature in the Antarctic.* **J. Rouch.** (Comptes Rendus, 171. pp. 866–868, Nov. 2, 1920.)—Observations of temperature made during an autumn and winter just within the Antarctic circle show that on days with the sky less than half covered with cloud there is, in addition to a maximum in the neighbourhood of noon, an additional maximum in the neighbourhood of midnight. This is not the case in spring and summer. Mean hourly values of temperature are given for autumn and winter, showing maxima in autumn about 2h. and 13h. and in winter about 1h. and 14h. In the latter case the "night" maximum is higher than the "day." The mean diurnal range in autumn is 2·8 deg. C., and in winter 1·1 deg. C. The diurnal variations of the other elements during the days considered do not appear to bear any relation to that of temperature. M. A. G.

613. *Chemistry of the Earth's Crust.* **H. S. Washington.** (Frank. Inst., J. 190. pp. 757–815, Dec., 1920.)—*Chemistry.*—Tables are given showing the distribution of igneous and sedimentary rocks in the crust, the latest estimates of the composition of the crust, and the relative amounts of the elements. The elements are referred to two main groups of the periodic table: (1) The petrogenic elements, characteristic of and most abundant in the igneous rocks, are of low atomic weight and occur normally as silicates, oxides, chlorides, and fluorides. (2) The metallogenic elements, rare or absent in igneous rocks, but occurring as ores of high atomic weight, and forming "native" metals, sulphides, arsenides, etc., but not primarily silicates. In igneous rocks and minerals the elements show a correlation, in that some of them are prone to occur with others. Moreover, the igneous rocks themselves occur in regions where they are chemically related—called "comagmatic regions" in America and "petrographic provinces" in England. The calculation of rock densities from their chemical composition is discussed, and the results are shown to confirm the theory of isostasy.

Earth's Interior.—Knowledge regarding the earth's interior is summarised. It is essentially a rigid solid; hot, with the temperature increasing towards the centre at a variable but unknown rate. Its mean density is about twice that of the crust. It acts as a magnet, and since the surface rocks are not very magnetic, this character may be attributed to its interior materials. The centre of the earth from about half the radius is composed of different materials, is of high density, and does not transmit torsional vibrations. The density cannot be accounted for by compression. The suggestion is made that below the silicate crust is a zone essentially of nickel-iron, and beneath this a central core of metallogenic elements. This agrees with the magnetism and density of the earth, and with Abbot's views as to the distribution of elements in the sun. W. A. R.

614. *Geophysics.* **W. Bowie.** (Nat. Acad. Sci., Proc. 6. pp. 545–555, Oct., 1920.)—*Geodesy.*—An outline of modern methods and aims of geodetic surveying is given.

Isostasy.—The history of the theory of isostasy is outlined, and its bearing on the determination of the figure of the earth pointed out. When taken into account, the flattening of the earth is found to be 1/297·4; and the depth of compensation 96 km. Gravity observations are not merely of value to the geodesist and the geophysicist, but under certain conditions they give information as to the extent of buried formations. They may thus help the economic geologist in his search for oil and mineral deposits.

Tidal Observations.—The value of Michelson's method for the determination of earth tides is emphasised, and an appeal is made to establish stations all over the world for observing earth tides by this method.

Latitude Variation.—The work of the International Geodetic Association is referred to throughout the paper, and its taking over of the determination of latitude variation is given in some detail. The results are of geodetic importance, and also enable the rigidity of the earth to be calculated. W. A. R.

615. *Strength of Rocks.* **J. Joly.** (Phil. Mag. 40. pp. 681–691, Dec., 1920.)—Apparatus and methods are described for determining the pressure at which cavities in small rock spheres will begin to close. Four rocks were tested, namely granite, basalt, obsidian, and lithographic limestone. The experiments indicate that at rather under 14 miles even at atmospheric temperature all cavities must close. Experiments at a pressure corresponding to 9 miles justify the assumption that at the probable corresponding earth temperature (450° C.) this pressure must be somewhere near the critical pressure for these materials. W. A. R.

616. *Displacement of Solar Lines towards the Red.* **M. v. Laue.** (Zeits. f. Physik, 3. 5. pp. 389–395, 1920.)—A theoretical treatment showing that the displacement towards the red of solar lines follows as a consequence of a law deduced by Hamel [Naturforscherversammlung, Nauheim] from the relativity theory. A. W.

617. *Solar Gravitation and Displacement of Spectrum Lines towards the Red.* **L. Grebe.** (Zeits. f. Physik, 4. 1. pp. 105–109, 1921.)—Rowland's measurements of lines from $\lambda 3870$ to $\lambda 3858$ are compared with those of Uhler and Patterson [Abs. 305 (1916)] for the same lines. After corrections are made for the Rowland scale a mean displacement for the 100 lines is obtained of 0·0063 Å.U. Adding to this St. John's value of 0·0019 Å.U. for the difference observed between light from the sun's centre and its edge, the total displacement becomes 0·0082 Å.U., corresponding to a velocity of 0·6 km./sec., in agreement with Einstein's theory. [See Abs. 380 and 596 (1921).] A. W.

618. *Note on Sobral Eclipse Photographs.* **H. N. Russell.** (Roy. Astron. Soc., M.N. 81. pp. 154–164, Dec., 1920.)—It has been objected, in reference to the Einstein theory, that some of the displacements of star images on the Sobral eclipse photographs are not strictly radial. The author is concerned with the reality of these anomalies and with a possible explanation. The comparison plates taken six weeks later prove distortion of the field at the time of the eclipse [see abs. 825 (1920)], and there is another comparative distortion due to differences of refraction at the heights in the two cases. After allowing for this, the author considers four possible assumptions. (1) That the gravitational displacement has the theoretical value and that there is no other distortion of the field. (2) That there is no distortion of the field, but that the gravitational effect is to be found from the observations. (3) That the gravitational effect has its theoretical value, and that there is an additional distortion of the field, expressible as a linear function of the coordinates x and y. (4) That this distortion exists, while the gravitational displacement is to be found from the observations. He obtains least-square solutions on each of the four hypotheses and finds solution (4) in extremely close accordance with the Greenwich result. He considers that unless the existence of a distortion is assumed, the residuals are too large. Therefore he claims that there is a proved distortion, and that it can be accounted for by an alteration of the cœlostat mirror by the sun's heat, introducing a cylindrical curvature of at least 12 km. radius—a very slight curvature and not improbable. W. W. B.

619. *Spectrum of Nova Cygni III.* **A. L. Cortie.** (Roy. Astron. Soc., M.N. 81. pp. 57–61, Nov., 1920.) [See Abs. 1572 (1920).] Stonyhurst observations of the nova began on Aug. 29, spectrograms being obtained at intervals from then till Oct. 18. The spectral changes were normal, the enhanced metallic line spectrum merging into the He-star type spectrum between Sept. 6 and 11. The average breadth of the H bands was about 20 Å. units. The bands were doubles and the radial velocity of the components was about 360 km per sec. In the composite band λ4640, O is probably present as well as C, N, and He.

The author suggests that the regime of changes of type F, A, B, P, O, corresponding to the fall in magnitude of novæ, can be explained by the formation of strong electric fields resulting from the cooling. *Spectrum of Nova Cygni III* 1920. (Roy. Astron. Soc., M.N. 81. pp. 50–51, Nov., 1920.)—Observations made at the Solar Physics Observatory, Cambridge, of Nova Cygni, include spectrograms indicating on Aug. 23 a velocity of approach of 365 km. per sec., and on Aug. 26 of 890 km. from H_γ and 870 km. from enhanced metallic lines (Ti, Fe, and probably Cr). A two-prism spectroscope was prepared by Sept. 6 and photographs were secured with it at intervals from Sept. 10 to 26. On Sept. 11, enhanced Fe and Ti indicated a velocity of approach of 735 km. per sec. The H lines which at that date appeared quadruple, indicated respectively, 810, 1220, 1370, and 1780 km. W. W. B.

620. *Periods and Light-Curves of 26 Cepheid Variables in Messier* 72. **H. Shapley** and **M. Ritchie.** (Mt. Wilson Observat. Contrib. No. 195. Astrophys. J. 52. pp. 232–247, Nov., 1920.)—Periods and light-curves of 26 Cepheid variables in Messier 72 have been determined from 18 plates taken with the 60-in. reflector. The variables are found to be much alike. The periods range from 0·33 to 0·66 day, and the median photographic magnitudes from 16·4 to 16·9, the mean value for all being 16·8. The difference of magnitude between these variables and the 25 brightest stars is unusually small, only 0·94.

Globular cluster Messier 72.—The photographic magnitudes of twenty-nine comparison stars were determined by the polar-comparison method. From the median magnitude of the variables the *parallax* of the cluster is computed to be 0·″000 030. AUTHORS.

621. *Elements of the Eclipsing System RT Lacertæ.* **M. Fowler.** (Astrophys. J. 52. pp. 257–262, Nov., 1920.)—*Eclipsing system RT Lacertæ.*—Luizet's observations, both 1910 and 1915, were reduced, a table of normals was prepared, the phases were slightly adjusted, and two sets of *elements* were computed, (1) assuming central total eclipses of two equal elliptical stars and (2) assuming an obscuration of 0·990. The *light-curve* at the minima is shown and a *diagram of the system*. In spite of the fact that the giant stars are less than a diameter apart, there is no evidence of an effect of radiation between them; on the contrary they seem actually less luminous at the limb than at the centre. The system would well repay spectroscopic study. AUTHOR.

LIGHT.

622. *New Spectropyrheliometer and Measurements of the Component Radiations from the Sun and from a Quartz Mercury-Vapour Lamp.* **W. W. Coblentz and H. Kahler.** (Bureau of Standards, Bull. 16. pp. 233–247 [Sci. Papers, No. 378], 1920.)—*Apparatus.*—This consists of a spectroradiometer employing a wide receiver which permits of measuring a wide range of the spectrum, and hence the whole spectrum in a few steps. The instrument is mounted equatorially, and, by means of a planocylindrical quartz lens, the solar image is focused lengthwise directly on the slit. This means of focusing enables the instrument to be readily operated without clockwork. The solar image travels slowly along the slit, and a series of readings may be made without resetting. The spectrum is produced by means of a quartz prism and two plano-convex quartz lenses. Relative measurements only being required, instead of a regular pyrheliometer, a specially constructed thermopile is used consisting of nine couples of bismuth-silver. The direct focusing of the solar image on the slit avoids the ultra-violet absorption in heliostat mirrors. The instrument may be used, amongst other things, for measuring the ultra-violet radiation from sources.

Results.—The particular result sought was a comparison of the ultra-violet component of radiation from the sun and from a quartz mercury arc-lamp. It was found that there is no marked difference in the total ultra-violet radiation of wave-lengths less than $0 \cdot 4\,\mu$, but the spectral distribution is different, the ultra-violet of the solar spectrum terminating at about $0 \cdot 3\,\mu$, whereas in the quartz mercury-vapour lamp the ultra-violet component less than $0 \cdot 3\,\mu$ is about 20 % of the total ultra-violet component. Some results were also obtained comparing the ultra-violet components of the radiation from the gas-filled tungsten lamp, the iron arc, and the carbon arc. M. A. G.

623. *Special Form of Phosphoroscope.* **W. S. Andrews.** (Gen. El. Rev. 23. pp. 856–857, Oct., 1920.)—The author has previously described a form of phosphoroscope for visual work [Abs. 914 (1917)]. The present paper describes a new type specially adapted for photographic work. A paper ribbon is first prepared by coating it with the phosphorescent material reduced to a powder, a chemically neutral adhesive being employed. When dry this is mounted on a cylindrical drum attached to the shaft of a motor. The exciting rays are generated by a disruptive discharge between two iron terminals concealed and protected within a circular hood, which is located close to the periphery of the drum. Diametrically opposite the spark-gap is a screen of sheet metal with a small window cut in it, exposing a portion of the ribbon. The discharge excites the material near it, and this is carried round to the window, where the phosphorescence can be examined. The action being continuous, it is easy to photograph the light given out by the substance under investigation, and a spectrograph will give an analysis of the light. Spectrograms of various substances are given. Fused cadmium phosphate was found to give white phosphorescence, and the admixture of manganese gave orange. Balmain's luminous paint gives phosphorescence in the blue-violet region, and willemite in the green. A. W.

624. *Number 7 Dial Sight.* **B. K. Johnson.** (Optical Soc., Trans. 21. pp. 176–185; Disc., 185–186, 1919–1920.)—Describes the methods adopted for testing this instrument and, incidentally, gives a description, illustrated with diagrams, of the method of working of the sight. Particularly the method of clamping the centre prism, so as to introduce the minimum of strain, and the test employed to detect the amount of strain present, are described. J. W. T. W.

625. *Subtractive Colorimeter.* **L. A. Jones.** (Optical Soc. of America, J. 4. pp. 420–431, Nov., 1920.)—Describes the construction and method of working of a colorimeter depending on the subtractive principle, *i.e.*, by the introduction of gelatine wedges which absorb the red, blue, and green components respectively, in front of a standard light source, which, in combination with a fixed filter, gives light of the same colour sensation as noon sunlight. For many classes of work the specification of colour in terms of the constants of the instrument is quite sufficient, but if it is necessary to specify in terms of hue and saturation the instrument can be calibrated by comparison with the monochromatic analyser. J. W. T. W.

626. *Errors in the Optical Observation of Distance.* **C. v. Hofe.** (Zeits. techn. Physik, 1. 4. pp. 85–90, 1920.)—In apparatus for the measurement of distance of far-away objects it is commonly found that there is a constant personal error, apart from the ordinary error of adjustment. Such devices depend on the exact adjustment of the space between two fine points, so that this corresponds with the apparent length of a distant object. During the war efforts were made to ascertain the cause of this error, but the experiments have not been completed. In the meantime a description of the author's apparatus and the results so far obtained is presented. The apparatus utilises two fine points, the distance apart of which can be varied and accurately measured. The apparatus permits of observations with the naked eye, or by the aid of optical assistance, either by monocular or binocular vision. Experiments were made with a great variety of markers of different shapes, used to measure vertical distance. It is shown that some forms are more favourable to accurate results than others. The accuracy of measurement naturally depends on the length of space between the dividing points, being apparently roughly inversely proportional to the sine of the angle of inclination subtended at the eye. Observations for the various markers are assembled in tabular form. In favourable circumstances acuteness of vision (represented by the reciprocal of the adjustment error expressed in degrees) attains a value of 2000 ($1{\cdot}7'' = 0{\cdot}0005^\circ$). J. S. D.

627. *The Surface Layers on Metals; Polarisation and Reflection Phenomena.* **H. Hauschild.** (Ann. d. Physik, 63. 9. pp. 816–844, Dec. 28, 1920.)—The objects of the present paper are to establish the influence which the surface layers of metallic mirrors exert on the state of polarisation of the reflected light, to investigate the conditions under which such layers originate, and to evaluate the optical constants of the pure metals free from superficial layers, using for this purpose artificial layers under circumstances which can be controlled. Part I contains a detailed account of the experimental arrangements, especially with respect to the interference phenomena in a combination of a Savart's plate with mica compensator. In Part II the theory of surface layers is derived from the Fresnel reflection formulæ, under consideration of the repeated reflections of the light rays which penetrate the layer. Part III contains the experimental results. The reflection formula was developed in a series for small layer thicknesses of 0·01 wave-length, and the influence of the second power of the thickness investigated. The changes observed for the optical constants of silver were satisfactorily accounted for by the formula, when molecular silver, taken as the layer, was assumed to possess the optical constants. Polished steel only appeared sensitive to atmospheric influences when moisture and CO_2 were simultaneously present with the oxygen. Treatment of polished nickel with linen, alcohol, or any other process, altered the direction of the polarised light. The optical constants of nickel were determined by change of layer thickness. This section also contains an account of the preparation of several artificial layers of measurable thicknesses; *e.g.*, by electrical deposition of silver iodide, production of the latter on silver mirrors by iodine vapour, kathodic pulverisation of a metal on the mirror, etc., this being followed by the determination of the optical constants of layer-free metals by means of inalterable layers. The results are unfortunately incomplete owing to the war. H. H. Ho.

628. *Absorption of a Goldberg Wedge in the Ultra Violet.* **F. C. Toy and J. C. Ghosh.** (Phil. Mag. 40. pp. 775–779, Dec., 1920.)—The absorption of light by the Goldberg wedge, a thin wedge of lamp-black and gelatine contained between inclined glass plates, is generally assumed to be constant throughout the visible and photographic spectrum. The authors have investigated the absorption curve by photographic means, using as a source of light either the electric glow-lamp or the mercury arc. It is found that while the absorption is very nearly constant throughout the visible spectrum (with a slight decrease from the yellow-green towards the red) yet in the ultra-violet, the absorption increases rapidly with decreasing wave-length. This increase of absorption could not be ascribed to the gelatine which, by itself, showed no variation up to 220 $\mu\mu$. The curve given in the paper shows, for a particular wedge, a density (in the photographic sense) at 330 $\mu\mu$ which is approximately double that at 450 $\mu\mu$. J. W. T. W.

629. *The Location of Interference Fringes.* **J. Guild.** (Phys. Soc., Proc. 33. pp. 32–39, Dec., 1920.)—The paper treats of the conditions under which interference fringes, produced by reflection of light from the two surfaces of a "thick plate," are visible to an observer. The treatment lays stress on the physical significance of the term "location" as applied to interference fringes, and the dependence of the observed phenomena on the conditions of observation. For a broad source of light a formula is obtained which is equivalent to that derived by Michelson. For a point source of light at infinity, it is shown that the fringes obtainable are equally visible at all distances from the plate. AUTHOR.

630. *Photographic Absorption and Extinction-Measurements. Contributions to the Study of Liquid Crystals. V. Extinction-Measurements.* **R. Riwlin.** (K. Akad. Amsterdam, Proc. 23. 5. pp. 807–816, 1921.)—In this paper a photographic method is explained for measuring absorption-spectra, and a preliminary application of it is made to the examination of the extinction of fluid-crystals. The object of the investigation is the examination of the way in which extinction depends quantitatively on wave-length, and especially to trace to what extent the difference, which Moll and Ornstein found between the phases ex-solid and ex-fluid in the ultra red, also exists for visible light. The method used has the advantage that the absorption for all colours is measured at the same time, and is produced in all spectral areas under identical circumstances. From the blackening, measured on the photographic plate, the intensity of the incident light is generally calculated according to the approximation-formula of Schwarzschild, $s = \log I \cdot t^p$, where s is the blackening, I the intensity of incident light, t the exposure-time, and p is a constant varying from plate to plate; but a method is now described whereby the use of this approximate law is avoided, the relation being found experimentally by constructing a blackening-scale on each plate. The blackening of the photographed spectra was measured with Moll's photometer. The regularity of the photographed spectrum depends greatly on the kind of developer, and glycine is found to be preferable even to hydroquinone. The extinction of para-azoxyanisol has been measured and the experimental details are fully described. The two liquid-crystalline phases, ex-solid and ex-liquid, are found to possess different extinctions also in the visible spectrum. [See Abs. 924 (1918).] **H. H. Ho.**

631. *Contact Setting of Small Discs.* **[Miss] A. B. Dale.** (Optical Soc., Trans. 21. pp. 187–193; Disc., 193–194, 1919–1920.)—French has given [Abs. 350 (1920)] values obtained for the apparent diameters of small bright circular discs against a dark background, the diameters being measured by setting the discs in tangential contact. For this purpose he used the two images of a circular object produced in the ordinary way by a double-image prism, the circles being set in and out of contact by a longitudinal motion of the prism. The present paper describes an improved method in which two double-image prisms were mounted one behind the other in a cylinder so that their relative orientation could be altered at will, the cylinder being placed on the table of a spectrometer. The object, a bright disc on a dark ground, or *vice-versa*, was placed about 5 m. away. Details are given of the method and of experiments carried out, and a theory is advanced to account for the phenomena observed. In the *discussion*, **J. Guild** pointed out that the results obtained, by demonstrating that the phenomena of contact setting of circular areas was the same for black circles on a white ground as for white circles on a black ground, disposed of any theory depending on the imperfect light insulation of the retina. **A. W.**

632. *Change of the Electric Double-Refraction with Temperature. The Kerr Constant.* **N. Lyon** and **F. Wolfram.** (Ann. d. Physik, 63. 8. pp. 739–752, Dec. 10, 1920.)—On Larmor's hypothesis of molecular orientation Langevin had calculated the electric double-refraction under the assumption that the molecules show, optically and electrically, the symmetry of a rotation ellipsoid. Enderle extended the formula to triaxial ellipsoids. The experimental results of Aeckerlein (nitrobenzene) were questioned by Voigt and by Himstedt [Abs. 430 (1916)]. The author tests the formula by observing the influence of temperature on the Kerr constant for the temperature range −80° to +18°. The liquid is introduced into a brass tube, 12 cm. long, 3 cm. diam., all contact with the air being carefully avoided. The optical arrangement is that of Lyon [Abs. 1253 (1915)]; the constants are taken from Landolt and Börnstein. Three liquids are tested, with special regard also to Born's suggestion [see Abs. 934 (1918)] that the Kerr constant of Langevin should be multiplied by a factor, slightly greater than 1, in accordance with the dipole theory of dielectrics of Reinganum and Debye. This dipole influence should be marked in the case of ethyl ether; but it was found that the values calculated after Born were higher than those after Langevin and those observed. Further precise determinations of the refractive index and the density of ether at low temperature are, however, desirable. In the case of the two other liquids, carbon disulphide and toluene, the agreement with Langevin was also better; as the temperatures were lowered the curves deviated more from one another, the calculated values being the higher. H. B.

633. *Testing Plane Surfaces by Interferometer.* **C. G. Peters** and **H. S. Boyd.** (Optical Soc. of America, J. 4. pp. 407–419, Nov., 1920.)—In testing the planeness of an optical surface by interference fringes in monochromatic light it is generally assumed that straight fringes equally spaced indicate planeness, and curvature in the fringes departure from a true plane. These assumptions are correct for normal incidence, but when the surface is viewed obliquely they may introduce considerable errors in the determination of planeness. The paper gives a theoretical discussion of the magnitude of the errors introduced in specific cases. For one per cent. accuracy the obliquity should not exceed $\tan^{-1}(1/7)$. J. W. T. W.

634. *Physical Meaning of Spherical Aberration.* **L. C. Martin.** (Nature, 106. pp. 469–471, Dec. 9, 1920.)—Describes the results of experiments on the effect of spherical aberration, using a fine pinhole in a silver film as source, with a well-corrected microscope objective of known elements. A nearly linear relation was found connecting the phase difference of the paraxial and marginal rays at the marginal focus, and the reciprocal of the tube-length. A perceptible loss of light from the central disc (estimated at 20 %) was found to occur when the residual aberration at the best visual focus amounted to $\lambda/4$. The sizes of the rings in the diffraction pattern at the best visual focus did not depart measurably from the theoretical values in the presence of residual aberration amounting to $0{\cdot}6\lambda$ at the focus where there is least confusion of phase. The "out-of-focus" appearances are described in the paper and have been photographed. The figure given in the article shows the ring system when a residual aberration, in the sense of over-correction, of $\lambda/2$ is present at the best focus, and when the reference plane was taken sufficiently far outside the focus to make the path-difference equal to $1{\cdot}8\lambda$. Publication of a fuller description of the results obtained is promised. [Erratum: *ibid.*, p. 567, Dec. 30, 1920.] J. W. T. W.

635. *Alteration of the Divergence produced by a Fresnel Lens.* **A. Blondel.** (Ann. d. Physique, 14. pp. 113–163, Sept.–Oct., 1920.)—When using very concentrated sources of high intensity with a system of Fresnel lens elements, it is sometimes desirable to increase the divergence of the resulting beam, either in the vertical or in the horizontal plane. The author shows that this is possible by means of a "correcting" globe or cylinder, placed so as to surround the source. Examples are given of the application of this principle in two principal cases: (*a*) that requiring the use of a globe of large refracting elements, each of which either magnifies or displaces the virtual image of the source of light; (*b*) that in which a globe of small elements causes the apparent surface of the source to be replaced by a large number of smaller sources very close to one another (termed the "polyeikon" arrangement). In this case, by suitable arrangement of the elementary beams produced by these small sources, the main beam may be either concentrated or caused to diverge. The method is suggested for lighthouse work. J. W. T. W.

636. *Fringe Systems in Uncompensated Interferometers.* **J. Guild.** (Phys. Soc., Proc. 33. pp. 40–51; Disc., 51–52, Dec., 1920.)—The paper mainly consists of an investigation of the form of the fringe system observable at infinity, or in the focal plane of a telescope, when a broad source is employed with a Michelson interferometer, in which the glass paths of the two interfering beams are not equal. The fringes may be elliptical or hyperbolic, with circles and straight lines as special cases. In the recently developed method of using the instrument for optical testing, the fringes due to a point source at infinity are employed. It is shown that the form of the fringes in this case is unaffected by lack of compensation, but that the visibility of the fringes is conditioned by the nature of the fringe system due to a broad source. AUTHOR.

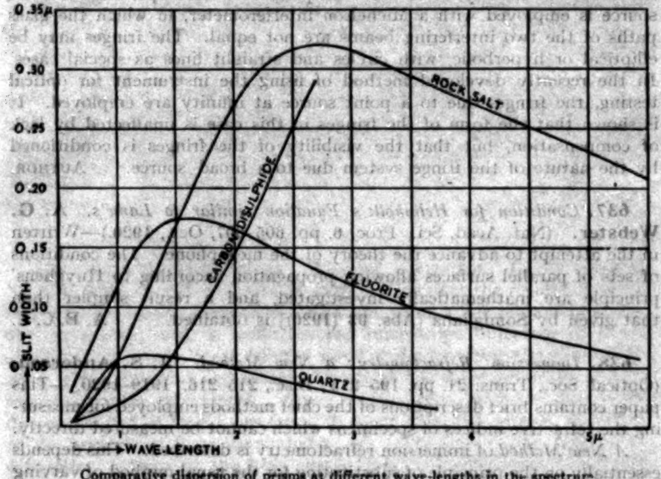
637. *Condition for Helmholtz's Equation similar to Lamé's.* **A. G. Webster.** (Nat. Acad. Sci., Proc. 6. pp. 605–607, Oct., 1920.)—Written in the attempt to advance the theory of the megaphone. The conditions of sets of parallel surfaces allowing propagation according to Huyghens' principle are mathematically investigated, and a result simpler than that given by Somigliana [Abs. 93 (1920)] is obtained. A. B. C. L.

638. *Immersion Refractometry; a New Method.* **J. S. Anderson.** (Optical Soc., Trans. 21. pp. 195–215; Disc., 215–216, 1919–1920.)—This paper contains brief descriptions of the chief methods employed for measuring the refractive indices of specimens which cannot be measured directly.

A New Method of immersion refractometry is described. This depends essentially on the principle of substituting for the usual method of varying the strength of the immersion liquid, a process which involves a few determinations of the wave-lengths for which the refractive indices of liquid and specimen are equal, corresponding to different strengths of the liquid. A number of alternative methods of observing the balance point of refractive index are given. Results by one of these methods were found to give for the C, D_1, and F lines a mean error of about 5 units in the fifth decimal place, though this error may be somewhat reduced by modifications of the optical systems employed. The method was employed with great success during the war in determining the types of glass used for the lens components of a number of captured German optical instruments. A. W.

639. *Inverting Prism; Improvement on the 45° Prism.* **T. Y. Baker.** (Optical Soc., Trans. 21. pp. 217–218, 1919–1920.)—The usual inverting prism has angles of 45°, 45°, 90°. In certain circumstances as large an aperture as possible may be required. The present note discusses the relationship of base angle ϕ to refractive index n in order to give maximum aperture, the incident beam being parallel to the base of the prism. A cubic equation is obtained connecting $\cos\phi$ with n. Only one root for $\cos\phi$ is admissible, and this has an approximate value $(7n + 6)/(10n + 3)$. A table is given showing the values of ϕ for values of n from 1·50 to 1·70. ϕ is seen to vary from 31° 57′ to 34° 32′. Tabulated values of the aperture ratio (Base/Maximum width of beam) for base angles 45° and 30° show that no great improvement is possible, but that a prism of angles 30°, 30°, 120° will in all cases be slightly better than the ordinary 45° pattern. A. W.

640. *Optical Data on Lens and Prism Materials used in Infra-Red Spectro-radiometry.* **W. W. Coblentz.** (Optical Soc. of America, J. 4. pp. 432–447, Nov., 1920.)—Gives a short description of the spectro-radiometer and of the materials used for the lenses and prisms for various



Comparative dispersion of prisms at different wave-lengths in the spectrum

spectral regions. Curves are given showing the width that a radiometer receiver of 4′ of arc subtends in wave-lengths in different parts of the spectrum produced by prisms of CS_2, quartz, fluorite, and rock-salt (see Fig.) This information is required for reducing the spectral energy distribution from the prismatic into the normal spectrum. It is seen that CS_2 is most useful for producing large dispersion in the region 0·5 to 1·5 μ. Quartz is most useful from the visible to 2·8 μ in the infra-red. Below this point it becomes too opaque. Fluorite is the best substance in the region of 2 μ to 9 μ, but is difficult to obtain. Rock-salt is next best, and may be protected from moisture by enclosing the spectrometer and keeping the prism covered when not in use. Sylvine is mainly useful from 10 to 20 μ. J. W. T. W.

641. *Aircraft Photography in War and Peace.* **H. H. Thomas.** (Soc. Arts, J. 68. pp. 749–753, Oct. 15; 763–766, Oct. 22, and pp. 777–781, Oct. 29, 1920. Cantor Lectures.)

642. *Michelson's Experiment.* **J. Villey.** (Comptes Rendus, 171. pp. 298–301, Aug. 2, 1920.)—The author continues his argument [Abs. 1170 (1920)] with Righi, criticising details of the latter's papers [Abs. 1498 (1919) and 1591 (1920)], and maintaining his contention that Michelson's experiment does lead to the conclusion that the ether as hitherto accepted must either be regarded as non-existent, or, with Sagnac, be reformulated in terms defined by the experimental results of Michelson and Sagnac. G. W. DE T.

643. *Discontinuous Heredity Actions and Spectral Lines.* **M. Brillouin.** (Comptes Rendus, 171. pp. 1000–1002, Nov. 22, 1920.)—A continuation of previous work [see Abs. 1275 (1919)] on the assumption that the speed of propagation of the action due to a moving electron within the atom is governed entirely by the positive nucleus, *i.e.*, this speed of propagation is a function only of the distance from the nucleus. It appears that this speed of propagation should be of the order of 1/100 to 1/1000 of the velocity of light in regions outside the atom, or 1/10 close to the nucleus. J. W. T. W.

644. *Colour Vision and Colour Blindness; New Spectrometer.* **F. W. Edridge-Green.** (Soc. Arts, J. 69. pp. 40–44; Disc., 44–47, Dec. 10, 1920.)—Colour blindness may be divided into three classes, namely, those involving (1) loss of perception of light as well as colour; (2) normal perception of shade but defect in perception of colour; (3) defective perception of colour owing to the region of the fovea not being normal, or supplied normally. The author has devised a spectrometer for testing colour blindness, enabling the exact size of the portions of the spectrum that appear monochromatic to be determined, and also the limits of visibility at each end of the spectrum. Most people can see six definite colours and will divide the spectrum into 18 regions that are apparently monochromatic. Exceptional persons see seven distinct colours, including indigo, and can detect as many as 25 distinct patches. Those with more or less imperfect colour-vision can only separate out a smaller number of patches than 18. Tests of engine-drivers and sailors should include the naming as well as the recognition of colours. The so-called wool-test is now obsolete and undoubtedly led to normal-sighted persons being regarded as colour-blind, and *vice versa.* In the *discussion* it was suggested that indications on railways might depend on the position of several white lights, thus eliminating colour-vision, but the lecturer considered that it seemed desirable to adhere to colour as a means of distinction. J. S. D.

645. *Results of Recent Investigations on the Theory of Development; Reduction Potential; Effect of Structure of Molecule of Reducing Agent upon its Reduction Potential; Fogging Power of Developers.* **A. H. Nietz.** (Phot. J. 60. pp. 280–291; Disc., 291–293, Dec., 1920. Communication from Research Laboratory of the Eastman Kodak Co.)—The work presented in this paper is a *résumé* of the results obtained in the last five years in an investigation of the whole theory of development, and, in particular, of that property of the developer to which is known as its reduction potential. If rate of development is measured, and it were possible to measure the resistance to development, a potential could be obtained which would be a measure of the reducing power of the developing agent. This potential of reducers is known in physical chemistry as the reduction potential. The following relations between the reduction potential and the photographic behaviour of a developer appear to be well founded: (1) The effect of bromide on a developer depends upon its reduction potential. If a developer is of low potential, a given amount of bromide will have a larger effect in lowering the density than it will if the developer has a high potential. This is exclusive of the effect of bromide on fog, which may be an important practical consideration. (2) The max. density tends to increase with increasing reduction potential. Maximum contrast, however, is not correlated with the reduction potential. (3) No definite relation can be shown to exist between the time of appearance and the reduction potential. Nor is K, the velocity constant, affected by the potential in any regular manner. The time of appearance depends largely upon the diffusion rate, and also upon the reaction resistance, either of which is necessarily influenced by the potential. (4) While the speeds of emulsions vary with the developer employed, they are apparently no function of the reduction potential. If high contrast is desired, and prolonged development is necessary to secure it, it will be desirable to use bromide to prevent the formation of fog; under these conditions a higher effective plate speed can be secured from a developer with a high reduction potential when using the amount of bromide necessary to eliminate fog. (5) The fogging power of a developer is not a function of its reduction potential.

It will be evident that factors, other than the potential, control the developing properties of organic reducers, so that the ordinary practical working properties of a developer are not satisfactory criteria of its relative energy. From an examination of a figure given it is evident that the aminophenols are the most energetic reducing agents, the hydroxyphenols next, and the amines the least. The introduction of a single methyl group in the nucleus, or in an amino group, raises the energy. The substitution of two methyl groups, however, is not always more effective than one. In opposition to the conclusion of Lumière, dimethyl paraminophenol is found to be a developer of greater energy than paraminophenol, though lower than the monomethyl compound. Nuclear substitution of a halogen in the hydroxyphenols raises the energy. The series of substituted paraminophenols was especially carefully worked out. In the case of nuclear methylation (one CH_3 group only) the energy is raised, but the increase depends on which position the methyl group occupies with respect to the other groups. *p*-aminocarvacrol has a very much lower potential than paraminophenol, which would indicate that further methylation or increase of the size of the molecule in that way is undesirable. Benzyl *p*-aminophenol gives a result which may be questioned, and it should be further studied. Introduction of another amino group greatly increases the energy. Chlorination of paraminophenol appears of doubtful advantage. Simultaneous nuclear and side-chain methylation (one CH_3 group for each) appears to give greater energy than either substitution separately. Change to a glycine lowers the potential, as does also the introduction of a $-CH_2OH$ group (Edinol). These results apply only to the groups in the position shown. The present data do not warrant further deductions, especially in view of the fact that the influence of the position of the groups is not yet known. In the course of the work a study is made of the fogging power of developers and of the distribution of fog over an image. A. E. G.

V.
19

646. *Size and Sensitivity of Grains in Photographic Emulsions.* **T. Svedberg.** (Zeits. wiss. Phot. 20. pp. 36–50, Nov., 1920.)—A general discussion of the question, together with description of experimental work and of the results obtained. In the first tabular and graphical results it is shown that for a photographic plate which is covered with silver bromide crystals in a single layer, the connection between lighting and blackening is shown by a curve analogous to the usual one obtained for thick layers. The connection between the percentage of grains and the log of the lighting value is also shown graphically. A certain S-formed curve is obtained for each size of grain, the max. values increasing with the decreasing size of the grains. Some experiments in which the action of H_2O_2 on the emulsion is studied are also described. A. E. G.

647. *The Present State of Photographic Optics.* **A. E. Conrady.** (Phot. J. 60. pp. 296–305; Disc., 305–307, Dec., 1920.)—This paper deals mainly with the Seidel theory and the alternative solutions of the problem of aberrations of oblique pencils which have been propounded independently by S. D. Chambers, and by the author. The most important result of the new discussion of the Seidel aberrations refers to astigmatism. A simple development is here given of the Seidel theory, which renders direct approximate solutions of all kinds of lens problems possible. A. E. G.

648. *Photographic Sharpness and Resolving Power.* **F. E. Ross.** (Eastman Kodak Co.'s Research Lab. Comm. No. 90. Astrophys. J. 52. pp. 201–231, Nov., 1920.)—*Photographic sharpness.*—The paper begins by summarising the more important relations between the fundamental photographic variables. It is found experimentally that for a considerable range of exposures the diameter Δ of an image is $\Delta = a + 2\kappa \log t$; or $\Delta = a' + 2\kappa' \log I$ (though the Greenwich equation $\Delta\tfrac{1}{2} = a' + b' \log t$ holds over a range 30 times greater). The constant κ is called the turbidity and is very nearly equal to κ', the ratio being Schwarzschild's coefficient p. The author derives the following formula for the intensity at various distances x from the edge of an image: $\log I = \log I_0 - x/\kappa'$, which is merely Beer's law for a homogeneous medium with extinction coefficient $1/\kappa'$; and sharpness, defined as the rate of change of density with x, is shown to be equal to the ratio of the contrast function γ to k. While actual *measurements of the variation of sharpness with wave-length and with time of development* prove this *theoretical expression for sharpness* to be but a first approximation, the equation indicates that to secure sharp images emulsions with both high contrast and low turbidity should be selected, also those whose characteristic curves have a small "toe." Various secondary factors which affect sharpness are discussed. Tugman's method of measurement was improved and extended to densities of about 3.

Resolving power of a photographic plate is shown to vary with the sharpness S and with the grain size d according to the *theoretical formula*: $R = 250S/(a + bd^2)\tfrac{1}{2}$. As an illustration, physical development of a Seed 23 plate gives images with one-fifth the sharpness obtained by chemical development, yet the grains were so much smaller that the resolving power was 20 % more. The theory also explains observed *variations with time of development and with wave-length, the effect of intensification*, etc. By taking pains to secure fine grains, the resolving power of a wet collodion plate may be made almost equal to the theoretical maximum for the lens used. It is suggested that astronomers are inclined to overestimate the advantage of small grain-size; for the true resolving power of some coarse-grained emulsions is far ahead of that obtainable with large telescopes. As a rule, what is needed is higher speed rather than better resolving power. AUTHOR.

649. *Polarisation of Refracted Light.* **P. Fröhlich.** (Ann. d. Physik, 63. 9. pp. 900–916, Dec. 28, 1920.)—A theoretical treatment is first given of the case of a ray of elliptically polarised light incident on the surface of separation of two isotropic transparent media, the ray being partly reflected and partly refracted, passing from the denser to the rarer medium. Various formulæ are derived, and experimental data are given in verification of these. A. W.

650. *New Effect of Polarised Light.* **F. Weigert.** (Zeits. f. Physik, 3. 6. pp. 437–459, 1920.)—Describes further work on the effect of polarised light on thin layers of photochloride. The results obtained are discussed and explanations suggested. [See Abs. 570 (1920) and 79 (1921).] A. W.

651. *The Faraday-Effect in Non-magnetic Metals.* **B. Pogány.** (Ann. d. Physik, 64. 1 and 2. pp. 196–208, Jan. 20, 1921.)—Further measurements have been made for the rotation of the plane of polarisation for non-magnetic films, namely, on Pd, Ag, Cu, Bi, and Cd, the experimental arrangement being that previously described [Abs. 56 (1918)]. The rotation is positive, except in the case of Bi. A very thin film of Bi (2·4 $\mu\mu$) shows positive rotation. The dispersion of the magnetic rotation has also been investigated. For Ag the dispersion is strongly anomalous (range λ 500 $\mu\mu$ to 650 $\mu\mu$), increasing linearly with the wave-length. Oxidised copper films show normal dispersion, while the reflecting films are anomalous. L. L.

652. *Influence of an Electric Field on the Fine Structure of the Hydrogen Lines.* **H. A. Kramers.** (Zeits. f. Physik, 3. 4. pp. 199–223, 1920.)—Following Bohr's treatment it is shown that the application of a weak electric field to the components of the fine structure of a line results in the production of one or more sharp polarised components, whose displacements are proportional to the square of the applied field. New components thus arise whose intensity increases with the square or some higher power of the electric field. With increasing field intensity the components remain sharp and polarised, and finally agree more and more nearly with the components given by the theory of the non-relativistic Stark effect, the displacements from the original line in this case being proportional to the first power of the electric field.

The latter part of the paper discusses the effect of an electric field on the series lines of the spectra of elements of high atomic number. [See Abs. 48 (1917).] A. W.

653. *Regularity in the Stark-Effect for Hydrogen and Helium Lines.* **U. Yoshida.** (Kyoto Coll. Sci., Mem. 4. pp. 187–199, July, 1920.)—From Stark's results for the displacements of the components of the Balmer lines at 104,000 volts/cm., tables of which are here given, it is

V.24
1921

seen that the distance between any two successive components of either the parallel or the perpendicular component of a line is constant, so far as they belong to the same line. Some exceptions from this rule are evident, especially in the case of H_γ. It is also interesting to note that all the perpendicular components of H_β occupy exactly the same positions as those of the parallel ones. The difference of displacements between any two neighbouring components of a line, when expressed in wave number, is very nearly constant in the case of H_α, H_β, and H_δ. And these constant differences in wave-number for these three lines are 6, 14, and 28 respectively, which are nearly integral multiples of 7. As regards the components of H_γ, although there are some exceptions, most of the differences of the two neighbouring components are nearly equal to 21 in wave-number, which again is a multiple of 7. Moreover, the displacements in wave-number of the components which are nearest to the original lines are nearly equal to some whole multiple of 7 in all the cases observed. Formulæ were sought to represent these results, and the following were obtained:

$$\Delta\nu_p = \{7/10\cdot 4\}\{p(m-2)-4\}E = 0\cdot 673\{p(m-2)-4\}E,$$
$$\Delta\nu_s = \{7/10\cdot 4\}\{p(m-2)-6\}E = 0\cdot 673\{p(m-2)-6\}E,$$

where $\Delta\nu_p$ and $\Delta\nu_s$ represent the displacement in wave-number of a component in the parallel and in the perpendicular component respectively, E is the field strength in 10^4 volts/cm., p are positive integers beginning from 1, and m is the term number of the series. Values calculated from these formulæ are seen to be in good agreement with the observed results. The formulæ are similar in some respects to that deduced theoretically by Epstein [Abs. 781 (1916)].

The Stark-effect for the *helium* lines is somewhat more complicated than that for hydrogen, and the results are discussed at some length. Similar formulæ were obtained for the lines of the diffuse series and for the lines supposed to belong to a series of isolated lines corresponding to the diffuse series. Observed and calculated values are tabulated, and the results for both hydrogen and helium exhibited graphically [see Abs. 1212 (1919)]. A. W.

654. *Line and Band Spectra of Iodine Vapour.* **K. Makino.** (Kyoto Coll. Sci., Mem. 4. pp. 169–171, June, 1920.)—The object of the experiments described was to determine under what electrical conditions of iodine vapour the line and the band spectra are emitted. By the use of a glow oscilloscope instantaneous current strengths in partial discharges emitting the line and band spectra were compared. Potential gradients in the path of these discharges were roughly determined, and it was found that the energy required to emit spark lines is roughly about five times that required to give the band spectrum. A. W.

655. *Spectrum of Bromine Vapour; Zeeman-Effect.* **G. Ribaud.** (J. de Physique, 7. pp. 205–208, Nov.–Dec., 1917.)—*Emission spectrum.* —With a Geissler tube discharge given by an accumulator battery, the tube having a large enough capillary, a spectrum of bromine vapour consisting of a large number of lines is obtained. The relative intensity of these lines depends on the conditions of the discharge. If the intensity of the discharge is increased, certain lines are reinforced, while others disappear. The addition of a capacity across the tube also causes some lines to disappear.

Zeeman-Effect.—If a Geissler tube is placed perpendicularly to the field of the electromagnet and strong fields are used, the apparent resistance of the tube becomes extremely high and the discharge requires therefore a very high potential. Moreover, the lines obtained are much broadened and difficult to measure. A tube was consequently introduced along the axis of the pole-pieces. The holes through the ends of the pole-pieces were about 7 mm. in diam. for about 2 cm. and then about 2 cm. diam., so that the capillary portion was very short, and the tube resistance as low as possible. Twenty-six lines were studied in the region λ4014 to λ5332, a Rowland concave grating being employed. The field, as measured by the Zeeman-effect on the zinc line λ4680, was found to be 21,800 gauss. The values of $\Delta\lambda/H\lambda^2$ for the majority of the lines are grouped about the values $1\cdot05 \times 10^{-4}$ and $1\cdot23 \times 10^{-4}$. Normal separation was not observed for any of the lines, but three of the lines, λ4766, λ4785, and λ4816, have a separation very nearly double the normal. [See Abs. 421 (1913) and next Abs.] A. W.

656. *Spectrum of Bromine.* **M. Kimura.** (Kyoto Coll. Sci., Mem. 4. pp. 127–149, June, 1920.)—*Line and Band Spectra; Arc and Spark Lines.* —The discharge tube used was similar to that employed for the study of the Zeeman-effect for chlorine [Abs. 437 (1921)], a small quantity of (usually) silver bromide being introduced into the side tubes. In some experiments sodium or potassium bromide was used. Excited by an induction coil, the discharge varied in colour with the vapour pressure and current density. With a very low pressure, a bluish-green light was emitted from the capillary portion of the tube, while the wider part gave a yellow light. With increased vapour pressure, the yellow colour changed to a pink glow and a deep pink light was given by the capillary portion. The spectrum of the light emitted by the wider portion of the discharge tube was found to be much simpler than that from the capillary portion. With a low vapour pressure, the wider part gave a system of lines and bands, the bands beginning at about λ5000 and extending beyond λ6600. These bands showed a fluted appearance and the heads of the bands were on the violet side. If the vapour pressure exceeded a certain value, the band spectrum disappeared almost entirely. Wave-length tables are given of the numerous lines measured, the stronger lines being classified as belonging to the arc or the spark type. Among the arc lines certain relationships were found, and a number of pairs of lines with constant frequency-differences are tabulated. Typical photographs of the spectra of the blue and pink glows, and emission and absorption spectra are reproduced.

Line Structures and the Zeeman-Effect.—The structures of lines in the bromine spectrum were examined with a 40-plate echelon grating. More than a dozen lines, belonging to the arc type, were found to have complex structures. The effect of a magnetic field on the complex lines λλ6632, 6560, 6351, and 6150 was investigated. It was found that these lines, although they have similar structures, were not affected in a similar manner by the magnetic field. In all cases satellites were found to be very sensitive to the action of the field. In strong fields they always gave triplets. The Zeeman-effect was also studied for a number of single lines. These all gave magnetic triplets, with wider specific separation than the normal, but the separations bear simple relations to the normal, just as in the case of chlorine. [See Abs. 2034 (1907).] A. W.

657. *Infra-Red Spectra of Isotopes.* **F. W. Loomis.** (Astrophys. J. 52. pp. 248–256, Nov., 1920.)—*Separation of the Infra-Red Absorption Doublets of HCl and HBr due to Isotopes ; Theory.*—If these bands are produced by the vibration of the nuclei along the line of centres of the molecules, the author shows that the frequencies should be approximately proportional to the square root of $(m_1 + m_2)/m_1m_2$; hence the band lines due to HCl^{35} and HCl^{37} should differ by 1/1330, and those due to HBr^{79} and HBr^{81} should differ by 1/6478. In the case of the HCl band at 1·76 μ, Imes found doublets whose components agree in separation and relative intensity with the theoretical results. In other cases the computed separations are less than the resolving power so far used.

AUTHOR.

658. *Revision of the Series in the Spectrum of Calcium.* **F. A. Saunders.** (Astrophys. J. 52. pp. 265–277, Dec., 1920.)—*A study of the triplet and singlet systems,* based on recent observations, including some *fifty new lines,* has led to the extension of most of the series, the calculation of the limits with greater precision, and the identification of various combination series. The diffuse series of triplets is extended to 15 terms and is shown to exhibit curious anomalies. Altogether, four triple-series of each system and eight probable combination series are given and also indications of three possible inter-system combination series. AUTHOR.

659. *Possible Influence of P.D. on the Radiation of the Tube Resistance Furnace.* **A. S. King.** (Mt. Wilson Observat. Contrib. No. 193. Astrophys. J. 52. pp. 187–197, Oct., 1920.)—*Radiation from the Tube Resistance Furnace.*—(1) *Effect of a small potential gradient.*—To determine whether, as Hemsalech asserts, the currents through the ionised vapour, produced by a potential gradient of 1 or 2 volts/cm. along the heating tube, were responsible for the emission of some of the furnace lines, a series of experiments was performed in which four different methods were used to reduce or eliminate the potential gradient acting on the vapour. In every case the relative intensity of the lines was found the same as with the higher potential gradient for the same temperature. No evidence of the alleged low-voltage arc spectrum superposed upon the furnace spectrum was found. (2) *Origin of the radiation.*—This result confirms the author's contention that whatever reactions between atoms or ions may cause the radiation, these reactions are caused and controlled by the high temperature alone, each temperature giving a definite spectrum. (3) The "*red fringe*" observed by Hemsalech is probably a chemical phenomenon, similar to a flame. It may be obtained when no p.d. is acting on the vapour. AUTHOR.

660. *Spectra of Compound Gases in Vacuum Tubes.* **W. H. Bair.** (Astrophys. J. 52. pp. 301–316, Dec., 1920.)—*Band spectra of six compound gases, in visible and ultra-violet regions.*—*Ammonia, nitrous oxide, nitrogen peroxide, carbon dioxide, hydrogen sulphide, and sulphur dioxide were excited* in an ordinary discharge tube, both with gas flowing and at rest, and spectrograms were secured with a three-prism glass spectrograph and with a small quartz spectrograph. The ammonia band in the visible spectrum has two heads, each degraded on both sides. The band at λ3371 is very probably not due to ammonia, as it is found in tubes long after the characteristic colour of ammonia has disappeared. Both oxides of nitrogen show strongly the *third positive group of nitrogen bands*, especially with the flowing gas. This group of bands was observed from λ3458 to λ1902; those at the more refrangible end appear not to follow Deslandres' law. Of the *two negative groups of carbon bands*, the first is probably due to CO and the second to CO_2. Several new bands were observed in this second group, and forty new bands were discovered in the spectrum of SO_2, extending this group to λ2124. AUTHOR.

661. *Grating Measurements in the Long-Wave Region.* **H. Rubens.** (Preuss. Akad. Wiss. Berlin, Ber. 1. pp. 8–27, 1921.)—The gratings used in the research here described were constructed of copper wires of diameters 1·004, 0·483, and 0·196 mm. respectively, the opening between the wires being equal to the wire diameter in each case. The gratings were 8 cm. square. With these and an arrangement of mirrors an investigation was made of the spectrum of the Auer burner in the region 0–200 μ, and of the radiation from the Auer burner reflected at the surface of fluorspar and rock salt. The results are presented in tables and graphs. The radiation from a quartz mercury lamp in the region 0–400 μ was also investigated. The results are discussed in relation to the quantum theory. [See Abs. 1612 (1920).] A. W.

662. *Negative Molecule Ions and the Spectra of Helium.* **F. Skaupy.** (Zeits. f. Physik, 3. 3. pp. 175–177, 1920.)—Chrisler [Abs. 2104 (1909)] has concluded, from experiments on the gas absorption in helium tubes, that negative molecule ions may exist, and Hamburger [Abs. 299 (1921)] finds that negative ions may consist of a greater number of atoms than positive ions in certain cases. The ordinary line spectrum of helium has more points in common with the spectra of the alkali metals than other spectra, and various considerations tend to the conclusion that this spectrum is due to the negative helium ion. If the existence of multi-atom negatively charged helium ions may be assumed, and the simple case is taken of two helium atoms with an extra electron, it is possible for this combination to give the many-lined spectrum of helium. A. W.

663. *Long Wave X-rays; Variation of Ionisation Current as Function of Applied Voltage.* **Holweck.** (Comptes Rendus, 171. pp. 849–852, Nov. 2, 1920.)—Experiments are described in which very soft X-rays are produced and studied. The exciting kathode-rays are produced in a tube containing electrodes 0·1 cm. apart, the accelerating field being supplied by a battery of small accumulators. This arrangement is necessitated by the fact that a strong thermionic current cannot be produced with low voltages unless the electrodes are very close together. Since the soft X-rays are so feebly penetrating, the producing apparatus (evacuated) and the ionisation chamber (containing gas) are separated only by a very thin membrane, sheets of celluloid 2×10^{-5} cm. in thickness being employed. The pressure in the X-ray tube itself was always less than 10^{-4} mm. of mercury. With this arrangement the author has detected the production of X-rays when the voltage between anode and kathode was as low as 70 volts. The wave-length of such X-radiation, determined from the quantum relation, is 175×10^{-8} cm., *i.e.*, one-sixth of that of the Schumann ultra violet.

An examination has been made of the variation of ionisation current (total absorption of radiation) as a function of the voltage applied to the tube. Above 300 volts, the ionisation increases very rapidly with the voltage; different gases (oxygen, nitrogen, acetylene) give similar results.

Effect of Nature of Anode Material on the Emission.—The effect of the nature of the anode material on the intensity and nature of the X-ray emission has also been studied, and measurements were made of the *coefficient of absorption of the rays in different gases.* A. B. W.

664. *Scattering of X-rays; Scattering Coefficient for Water.* **F. Dessauer.** (Phys. Zeits. 21. pp. 571–572, Nov. 1 and 15, 1920. Paper read before the 86. Naturforscherversamml., Nauheim, Sept., 1920.)—A commercial gas-free X-ray tube (Coolidge tube) was excited with three different voltages, 162·5, 181·5, and 200 kv. and the resulting radiation filtered through 0·5, 0·8, and 1·3 mm. of copper. The transmitted radiation was then passed into a Seeman spectrograph and photometric record made of its spectrum. In this manner three relatively narrow ranges of rays of known spectral breadth were obtained. Using these three rays a determination was made of their absorption (μ) and scattering coefficients (s) in water (a homogeneous medium). It was found that the scattering coefficient s for water was practically the same for all three hardnesses, namely $s = 0{\cdot}06\ \text{cm}^{-1}$. This value is considerably smaller that that found by Barkla, $s/\rho\text{Al} = 0{\cdot}2$, or by Hull and Rice $s/\rho\text{Al} = 0{\cdot}12$. It is more nearly in agreement, however, with the value $s/\rho\text{Al} = 0{\cdot}04$ obtained by Ishino for the RaC γ-rays in aluminium, and with the measurements of Dessauer and Black with hard X-rays (0·046 for 170 kv. for Al). A. B. W.

665. *Spectrum Analysis of the Canal and Kathode Rays of Positive Point Streams in Oxygen and Nitrogen.* **A. Schultz.** (Ann. d. Physik, 64. 4. pp. 367–376, Feb. 24, 1921.)—Weth has recently (1920) published results of some spectrographic experiments on the positive point streams in hydrogen which were in accord with the theory of J. Stark on positive point streams. It therefore appeared of interest to undertake experiments with positive point streams in other gases. It is now found that in the spectrum of the positive point stream in oxygen, spark lines, series lines, double lines of the second arc spectra, the first band spectrum, ozone bands appear; while in nitrogen there appear negative bands, positive bands, and spark lines. In the positive point stream there are slow kathode rays, quick kathode rays, and slow canal rays. The carrier in the series lines of oxygen is a singly-charged atom ion, in the spark lines a doubly-charged atom ion. The carrier in the negative bands of nitrogen is a doubly-charged diatomic molecule (N_2^{++}), that of the positive bands a singly-charged diatomic molecule (N_2^{+}). In the canal rays of the positive point stream, discharge takes place in oxygen from the doubly-charged to the singly-charged atom ion; in nitrogen, from the doubly-charged to to the singly-charged molecule ion. A. E. G.

666. *Fine Structure of Röntgen Spectra.* **A. Smekal.** (Zeits. f. Physik, 4. 1. pp. 26–45, 1921.)—Exposition of the arguments outlined in Abs. 1289 (1920) concerning a twofold extension of the views of Kossel-Sommerfeld: (1) Each independent configuration or shell of electrons is given, in addition to the two quantum numbers of the planar model distinguished as radial and azimuthal, a third quantum number which may briefly, though inexactly, be referred to "spacial quantising"; (2) the coordination of an electron to a definite shell is determined only by the sum of the three numbers, and since such a sum may have several component triplets, the electrons of the same shell need not energetically be equivalent. According to Sommerfeld (Ann. d. Physik, 51. p. 125, 1916) some lines of "hydrogen similarity" must at least be assigned to the innermost shells of shortest waves. From (1) can be deduced the numbers of all the absorption edges, also of those "not of hydrogen similarity," of the several Röntgen series; the selective principle does not appear to hold for these energy levels. An attempt is made to explain the fine structure of K_α by (2). It is found that (*a*) the L series has only three absorption edges; (*b*) the Λ doublet of the L series is not real; (*c*) the lines $K_{\alpha 3}$ and $K_{\alpha 4}$ of Siegbahn, as well as Hjalmar's new lines $K_{\alpha 5}$ and $K_{\alpha 6}$ [Abs. 1176 (1920)] have, like K_α, original levels of two quanta. H. B.

667. *The Emission of Secondary X-rays in the Coolidge Tube.* **F. Canac.** (J. de Physique et le Radium, 1. pp. 123–125, Oct., 1920).—A short description of experiments carried out with two Coolidge tubes, details of the differing antikathodes of which are given. Platino-cyanide photographs of the secondary emissions are shown. B. J. L.

668. *Continuous Röntgen-Ray Spectrum.* **H. Behnken.** (Zeits. f. Physik, 3.1. pp. 48–59, 1920. From the Physikal.-Techn. Reichsanstalt.)—Einstein's quantum formula $eV = h\nu$, is applicable to the continuous Röntgen-ray spectrum if ν is the maximum frequency occurring in the continuous spectrum, V is the potential applied to the Röntgen tube, and e and h have the values $4 \cdot 774 \times 10^{-10}$ e.s. unit and $6 \cdot 52 \times 10^{-27}$ erg. sec. respectively. The formula can be transformed to $E . \lambda_0 = 12 \cdot 3$ where E is the potential in kilovolts and λ_0 the shortest wave-length, measured in Ångstrom units.

Experiments were undertaken with a Coolidge tube, the potential required being obtained from a transformer fed from a 5-kw. generator giving a good sine-wave current of 50 periods. Ten curves are given of results obtained with this apparatus, and tabulated results show excellent agreement with the above formula. Variations of current strength through the tube from 1 to 6 milliamps. had no effect on the results. The energy distribution in the continuous Röntgen spectrum, and therefore the mean hardness of the tube used, was found to be independent of the current variations. A. W.

669. *The Phosphorescence of Oxygen Compounds of the Alkaline Earth Metals.* **F. Schmidt.** (Ann. d. Physik, 63. 3. pp. 264–294, Oct. 7, 1920.)—According to Lenard [Abs. 726 (1905)] the sulphur of the alkaline earth compounds containing also traces of some heavy metals stores the electrons, which are discharged by this latter metal during excitation, to return them to the metal during the phosphorescence. The sulphur in these phosphores has been replaced by selenium and tellurium by Pauli [Abs. 236 and 1023 (1911) and 1702 (1912)], by J. Hirsch (dissertation, Heidelberg, 1912), and F. Kittelmann [Abs. 1050 (1915)]. The author studies oxygen phosphores. The carbonates of Ca, Sr, Ba are heated partly to expel the CO_2, mixed with small quantities of some alkaline flux (halides, phosphates, borates), ground up with the heavy metal salt, generally nitrate of Cu, Bi, Mn, Pb, and heated to incandescence, dull red to yellow glow; the proportions are, *e.g.*, CaO 1 gm., NaCl 0·1 gm., Cu 0·0001 gm., red glow for 16 minutes. According to Hirsch the final product, which is kept sealed in glass, must contain carbonate; according to the author the Ca phosphores, which contain less CO_2 than the Sr and Ba phosphores, are the most phosphorescent. The preparation of a great many of these various compounds is described. The excitation is effected after Ciechomski by an Al arc (continuous spectrum down to 220 $\mu\mu$) under water; the two horizontal Al rods are threaded in their brass-ebonite box so as to keep the gap of 2 or 3 mm. at the same place; the water circulates through the box, which is provided with a quartz window. The phosphore to be excited is spread in an Al pan in a layer of 1 mm. thickness, the pan being electrically heated. The observations are supplemented by experiments with a magnesium arc, also under water. The excitation is instantaneous or of some duration (up to 6 mins.), and by various ultra-violet radiations; the colour of the phosphorescence (red, yellow, green, blue) for the different compounds, varying with the composition and the proportions of the constituents, is not affected by the excitation, and Stokes' law holds throughout. Excitation by kathodic bombardment produces a very intense momentary phosphorescence with the bands of the long-duration excitation by the arc, in addition to a faint general luminescence. The oxygen phosphores require heating to higher temperatures than the others to give the intense duration-phosphorescence. At ordinary temperature the phosphorescence is weak. The most intense phosphorescence and the bands occur in O compounds at shorter wave-length, and in Se compounds at longer wave-lengths, than in the S phosphores. The statements of Hirsch are on the whole confirmed. As regards the dielectric constants, compare F. Schmidt [Abs. 1606 (1914) and 888 (1915)]. H. B.

670. *Luminescence of Samarium.* **H. L. Howes.** (Phys. Rev. 17. pp. 60–63, Jan., 1921. Chem. News, 122. pp. 55–56, Feb. 4, 1921.)—*Luminescent Spectrum of Samarium Oxide in Calcium Oxide.—The effect of heat treatment* was studied by comparing the kathodo-luminescent spectra given by fresh preparations which had been carefully heated at various temperatures ranging from 200° to 3000°. The intensity of the light emitted increased with the temperature of heating, but no variations in the wave-lengths of the very narrow bands was observed. Thirteen *new bands* were discovered and measured which help fill out the eight series of constant frequency-intervals.

Thermo-luminescence of Samarium Oxide in Calcium Oxide.—The minimum temperature was found to be about 200°. AUTHOR.

671. *Scattering of Light by Unsymmetrical Atoms and Molecules.* **J. J. Thomson.** (Phil. Mag. 40. pp. 393–413, Oct., 1920.)—Investigations of the scattering of light by small particles have hitherto been confined to symmetrical arrangements of the electrons in an atom, in which case the displacement of an electron due to an external force will always be in the direction of that force, and the ratio of the displacement to the force will be independent of the direction of the force. The intensity of the scattered light is then found to vanish along the direction of the electric force in the incident light if this be plane-polarised. If not polarised, the scattered light when observed in a direction perpendicular to the incident light is found to be completely polarised. In this paper it is shown that when the atom is unsymmetrical and the displacement of an electron is not necessarily in the direction of the disturbing force, the intensity of the scattered light will not vanish in any direction: it, however, varies with the direction, and experiments on the law of variations, such as Rayleigh's, give valuable information about the structure of the atom. It is first shown analytically that, so long as the frequency of the incident vibrations is large compared with the free frequencies of the electrons, the scattering of light will be as in a symmetrical system, but, in general, not otherwise. A general expression is obtained for the energy of the scattered light, from which it appears that, in the case of polarised incident light, the minimum value of the intensity of the scattered light will be one half the maximum when the incident light has the same period as one of the free vibrations of the atom, while for greater frequencies the minimum intensity may be greater than this. In the case of unpolarised incident light the minimum intensity will always be greater than half the maximum, except for a symmetrical atom, in which case it is equal to half the maximum. With symmetrical atoms or isolated electrons the scattered light reaching a point P will be in the same phase from whichever atom it may proceed; so that with N atoms the magnetic force will be proportional to N, and the scattered light-intensity to N^2. With unsymmetrical atoms the phase will partially depend on the orientation of the atom, and the scattered light-intensity will vary partly as N and partly as N^2. The latter portion tends to vanish relatively to the former when the atoms occupy a considerable volume and are distributed at random. The scattering due to a gas or liquid may therefore be taken as proportional to N, but this will not be the case if the atoms are arranged in a lattice, as in crystals. In the analysis three mutually rectangular directions are assumed in the atom, such that the electrons can be displaced along any one without causing any displacements along the other two. Then if ξ, η, ζ are the three displacements, the equations of motion are $m\ddot{\xi} + A\xi = F_1$, etc., where A is the restoring force, and F_1 the external force along the direction ξ, etc.; and if the external forces vary as ϵ^{ipt}, the solutions are $(\xi, \eta, \zeta) + (a, b, c)$, where $a = 1/(A - mp^2)$, etc. It is then shown that the ratio of the minimum to the maximum intensity of scattered polarised light can be calculated when the values of a, b, c are known, and these are determinable when the arrangement of electrons in an atom are known. The author calculates the values of a, b, c for some specified types of atoms: (1) when the electrons in the undisturbed atoms are describing circular orbits; (2) when they are in equilibrium. In (1) a small disturbing force $X \cos qt$ parallel to x is assumed in the plane of the orbit described, with a force $\mu r/(r^2 + d^2)^{3/2}$, where r is the distance from a point in the plane of the orbit, and d a constant. The ordinary analysis of planetary theory is employed to determine a, b, c. As an example, a H molecule with two + charges and two electrons at the corners of a rhombus would mean a 0·4 % ratio of minimum to maximum intensity. And Rayleigh's experiments show that for H the value is at least ten times greater. (2) The electrons are assumed to be in equilibrium under mutual forces which do not, at the distances which separate the + charges from the outer ring of electrons, vary inversely as the squared distance, but at these distances may vanish and change from attractions to repulsions. As an example, take a H molecule with the two electrons and + charges at the corners of a square. Let r be the distance of the electron from the + charge, then the attraction between them is $e^2/r^2 . \phi(x)$, where $x = c/r$, c being a constant. Then for $x = 0$, $\phi(x) = 1$; and $\phi(x)$ must be of the form which will give the Balmer series in the H spectrum. These do not completely determine ϕ, but it is shown to be possible to find an expression for ϕ which satisfies these conditions and gives a scattering ratio of a little less three per cent., Rayleigh's experimental value being a little less than 4 %. It has been urged against the assumption of a force not varying as the inverse square that the scattering of alpha particles indicates a force of this type. But the author points out that this scattering is practically confined to central distances very small compared with the distance of the electrons which effect the scattering or affect the visible light, and that it is quite possible to have the inverse square laws at very great and very small distances, compared with c, coupled with a law of quite different character where r is comparable with c. G. W. de T.

672. *Diffused Reflection and Transmission of Light.* **A. P. Trotter.** (Illum. Eng., London, 12. pp. 243–267, Sept., 1919.)—I. *Diffused Reflection.*—Lambert's account of regular and of scattered reflection, and the well-known Lambert's law of illumination, together with his observations on brightness of unpolished surfaces are given in literal translation from "Photometria," published in Latin in 1760. Bouguer's experiments, illustrated by polar curves and reference to his hypothesis of scattered reflection, are translated from the French, published in 1729. The investigations of Lommel, Blondel, Christian Wiener, and H. R. Wright are summarised and discussed.

The author's work, begun in 1891 and suspended in 1914, is described. It is shown how specular reflection can be separated from diffused reflection by drawing an internal osculating circle, instead of the circumscribing circle of Bouguer and Blondel, and how, when rectangular coordinates are used instead of polar, diffused reflection is represented by a curve, in some cases closely representing the probability curve or curve of frequencies, and it is suggested that there is a rational connection with the statistical function. The author's apparatus is described and numerous examples of his results are given. He incidentally found that the brightness of a matt surface varies with the angle of aspect or emission.

II. *Diffused Transmission.*—Starting in 1883 from an investigation of the difference in scattering of light by the grease spot and by the paper of a Bunsen screen, many experiments were made with various materials. Graphical analysis as used in Part I yielded curves closely resembling the curve of frequency or probability. His intention was to study various kinds of opal glass, and so to classify and describe their optical characteristics, but the research remains unfinished. Author.

HEAT.

673. *Expansion of Glass at High Temperatures.* **W. B. Pietenpol.** (Chem. and Met. Eng. 23. pp. 876–877, Nov. 3, 1920.)—Describes experiments for the determination of the thermal coefficient of expansion of glass strips about 76 cm. long. The expansion of optical and other glass was measured from room temperature to 750° C. The rate of expansion is constant up to 450° to 550° C., depending on the kind of glass. It then becomes zero for a range of 60 to 100 deg., is then very rapid for slightly higher temperatures, finally settling down to another constant value at which it remains until the softening point is reached.

J. W. T. W.

674. *New Method of Determining the Mechanical Equivalent of Heat.* **T. H. Laby** and **J. K. Roberts.** (Roy. Soc. Victoria, Proc. 32. pp. 148–155, Sept., 1920.)—The method described involves the heating of a copper cylinder by a rotating magnetic field. During the experiment only stationary temperatures are dealt with, and only a small fraction of the heat developed is lost. Only preliminary determinations have been made up to the present, but it is hoped to attain, if possible, an accuracy of 1 part in 10,000 in J, the mechanical equivalent. A rotating magnetic field, with a known and fixed axis, is obtained by the rotation of an electromagnet. A copper cylinder is mounted so as to be capable of rotation about the same axis. The work done on the copper cylinder is found as in Rowland's experiment. The copper cylinder is attached to a vertical axle and wheel (of diameter D cm.), and the whole is suspended by a torsion wire. Two wires pass round the circumference of the wheel, and over pulleys to two masses of m gm. The couple mgD dyne cm. produced by these weights balances the couple arising from the rotating magnetic field. The torsion wire gives stability to the system. The heat developed is measured by a continuous flow method. Water flows past a Pt thermometer, then circulates round the copper cylinder and out past a second Pt thermometer. The heat developed is $M(\theta_2 - \theta_1)$ cals., where M gm. is the quantity of water flowing in an experiment, and $(\theta_2 - \theta_1)$ is the rise of temperature. To eliminate the heat losses, L cals., from the expression for J, two experiments are made, a heavy and a light one, in which θ_1 and θ_2 are the same. The heat developed in the former is about 10 times that in the latter. Hence $J = \pi Dng\,(m_1 - m_2)/\{(M_1 - M_2)\,(\theta_2 - \theta_1)\}$, where n is the number of revolutions of the field magnets for the period of an experiment, which is the same for the light and heavy runs.

The heat developed in the light run is made less than in the heavy run by reducing the strength of the magnetic field. This is effected without altering the current in the field coils. Each of the two poles has a double winding, the current flowing in the same sense through each pair of coils for the heavy runs, but in the light runs the connections to one of the coils on each pole are reversed, so that the field strength is reduced.

The design and operation of the apparatus is discussed, and numerous photographs are given of the different parts. [See also Abs. 723 (1921).]

A. W.

675. *Report of Standards Committee on Pyrometry,* 1919. **W. E. Forsythe.** (Optical Soc. of America, J. 4. pp. 305–336, Sept., 1920.)—This Report is a collection of miscellaneous information which is useful to persons interested in pyrometry. It is concerned mainly with the disappearing-filament pyrometer [see Abs. 479 (1921)]. In addition it describes generally the methods of establishing and maintaining a high-temperature scale. A table is included which gives the relative energy of a black body for temperatures between 1000° and 5000° abs. for a number of wave-lengths in the visible spectrum. This table is calculated from Wien's equation, using a value of 14,350 μ degrees for the constant C_2. Curves are given showing the temperature corrections for the absorption of glass or mica windows between the furnace and pyrometer, and also tables showing the emissive powers of many metals at high temperatures and the corrections to be added to their "brightness" temperatures in order to obtain their true temperatures. E. G.

676. *The Heat of Sublimation of Carbon.* **H. Kohn.** (Zeits. f. Physik, 3. 3. pp. 143–156, 1920.)—In 1914 Lummer investigated by an optical method the dependence of the temperature of the positive crater on the pressure under which the carbon arc burnt. Later [see Abs. 173 (1921)] Fajans, in an investigation on the heat of sublimation and the valency forces of carbon modifications, sought to find whether this dependence could be established from a vapour-pressure curve for carbon, to which the Clausius-Clapeyron equation could be applied. Between 0·1 and 1·0 atmo. exceedingly good agreement with theory was established, *e.g.*, the sublimation heat of carbon at 4200° abs. was found to be 282·5 kg. cals. under atmospheric pressure, while that calculated for the diamond is 287 kg. cals. on the assumption of the monatomic character of carbon vapour. At pressures above atmospheric (1 to 22 atmos.) the Clausius-Clapeyron equation became invalid. The present author now investigates the temperature curves anew. Section 1 deals with the relationship between pressure and surface brightness. Section 2 considers measurements at low pressures, and Section 3 at pressures above atmospheric. It is shown that the temperature curves of the positive crater of the arc light under higher pressures, using pure carbon, can be regarded as vapour-pressure curves of carbon. This result was only found by Fajans for low pressures. The Fajans calculations for the heat of sublimation of carbon, which were based on the inexact temperature values in Lummer's treatise, are now corrected by the use of more exact data. From over- and under-pressure measurements between 0·3 and 8 atmos., the heat of sublimation of carbon, corresponding to a temperature interval of about 4000°–4700° abs., has the value 163·5 kg. cals., whereas the value of 168 kg. cals. follows for that of the diamond at room temperatures. The latter value approximates to the 142 kg. cals. which is obtained from the integrated vapour-pressure formula by insertion of the theoretical value for the chemical constant of a monatomic gas. This agreement is mainly the consequence of corrected temperature values. H. H. Ho.

677. *Emissivity of Iron and Copper.* **K. Lubowsky.** (Elekt. Zeits. 42. pp. 79–81, Jan. 27, 1921. Comm. from the Testing Department of the A.E.G.-Grossmaschinenfabrik.)—Describes a determination of the emissivity of iron and copper, both bright and when blackened, in air.

The effect of the convection currents is shown by the different curves obtained with a flat plate of the material (*a*) perpendicular to, and (*b*) in the direction of the air stream. The emissivity, expressed in watts per cm.^{2} per 1 deg. C. of temperature excess varies from $0{\cdot}75 \times 10^{-3}$ to $1{\cdot}5 \times 10^{-3}$ under the various conditions. J. W. T. W.

678. *Radiation in Hydrogen and Air Explosions.* **W. T. David.** (Roy. Soc., Proc. 98. pp. 183–198, Nov. 3, 1920.)—The pre-war experiments here described were carried out with the same apparatus, and in continuation of, those on mixtures of coal gas and air previously described [Abs. 1703 (1911)]. The following results were obtained (*a*) with the vessel coated with a thin layer of black paint; (*b*) with the silver-plated vessel, which could therefore be made either reflecting or absorbent as regards radiation. (*a*) The heat of combustion loss by radiation during explosion and subsequent cooling decreases greatly with the mixture strength. The total radiation is a linear function of the max. absolute temperature, and is a maximum at the max. temperature. Weak mixtures radiate more in the initial cooling stages than stronger mixtures, after cooling to the same mean temperature as the weaker. The rate of radiation in the strongest mixture is approximately proportional to the fourth power of the absolute temperature: in weak mixtures this proportionality holds in the later cooling stages. The 2·8 μ emission band of steam disappears when the temperature falls to about 1000° C. abs. Radiation of greater wave-length containing appreciable energy is apparently emitted at this temperature. At the highest temperatures in the 25·4 per cent. mixtures, radiation of shorter wave-length than 2·8 μ appears to be emitted. (*b*) The rate of emission from unit solid angle (Callendar's *intrinsic radiance*) at any given temperature after explosion increases greatly as the reflecting power of the interior surface of the vessel is increased, and therefore with the size of the vessel. The mixtures after explosion are very transparent throughout cooling to radiation of the kind they emit. The (*b*) experiments confirm the author's former conclusion that the vibration energy depends on volume as well as temperature, and the whole range of phenomena in the H mixtures is of the same general character as in the coal-gas mixtures. The notable difference that the rate of emission in the H mixtures is not a maximum during the explosion period, as it is in the coal-gas mixtures, appears to militate against the author's former suggestion [*loc. cit.*], that the energy of combination first passes, wholly or in part, into the form of intramolecular energy and is afterwards partitioned off in part into translational energy. But he suggests as a possible explanation that the combination between H and O may be completed so rapidly, relatively to the combustion of hydrocarbon molecules, as to result in the volume of the H mixtures undergoing combination at any instant forming an infinitesimal fraction of the whole, even during the period of greatest chemical activity, so that the influence of the latter on the total radiation would not be detectable. The much more rapid decrease with the mixture strength, of the heat of combustion lost by radiation during explosion and subsequent cooling, in the H mixtures than in the coal-gas mixtures appears to be accounted for by the results of the author's analysis of the radiation in the two classes of mixture [Abs. 405 (1920)], in that the exploded weak H mixtures spend a relatively short radiating period at temperatures at which the 2·8 μ band, containing the bulk of the radiation energy, and the coal-gas mixtures a much longer period, due both to slower cooling and the emission of a strong 4·4 μ band of CO_2 which continues at temperatures at which the 2·8 μ band is no longer emitted. The experiments in the present paper on the relative emission of radiation through quartz and fluorite screens appear to throw light on the considerable increase of the specific heat of steam with temperature observed by Holborn and Henning [Appendix to final report of B.A. Committee on Gaseous Explosions]. For the emission spectrum of steam (H flame) consists essentially of a strong 2·8 μ band, and these experiments indicate that the energy in the vibratory degrees of freedom corresponding to radiation of this wave-length is inappreciable at temperatures below 700° C. (1000° C. abs.), but above this temperature these degrees begin to share to a rapidly increasing extent in the heat motion of the molecules. G. W. DE T.

679. *Molecular Energy in Gases.* **J. A. Ewing.** (Roy. Soc. Edinburgh, Proc. 40. pp. 102–111, 1919–1920. Abstract of Address. Engineering, 109. pp. 842–844, June 18, 1920.)—Experiments on the specific heats of gases and on their infra-red emission and absorption from low temperature up to 2000° C. have done much towards showing how the molecules take up energy during heating, and have raised questions how far Newtonian dynamics suffice and how far the quantum theory is suggested or appears necessary. Some of these questions the author formulates without attempting categorical answers, which must await more definiteness in the physical concepts underlying the quantum theory, and embodies the results of a review of the known facts in the following conclusions:— (1) The increase in specific heat which is observed to occur in most gases when they are heated is due to the setting up of to-and-fro vibrations of the atoms composing the molecules. The principle of equipartition does not apply to these vibrations. (2) In monatomic gases substantially all the energy, so far as that is communicable, consists of energy of translation. Accordingly the specific heat is sensibly constant, C_v having the value $\frac{3}{2}$R and γ the value $1\frac{2}{3}$. (3) In diatomic gases, under normal conditions, the energy consists mainly of energy of translation and energy of rotation about axes transverse to the line joining the two atoms. The specific heat C_v is approximately $\frac{5}{2}$R, and two-fifths of this quantity is accounted for by there being two (and only two) effective degrees of freedom of rotation. The normal value of γ is accordingly $1\frac{2}{5}$. When the gas is cold the energy of vibration is nearly negligible, except in certain gases such as the vapours of the halogen elements, where it forms an appreciable part of the whole energy even at ordinary temperatures. When a diatomic gas is heated the to-and-fro vibration of the atoms comes increasingly into play and contributes a substantial addition to the energy, with the result that the specific heat rises, and γ falls below $1\frac{2}{5}$. (4) In all gases at all temperatures there is equipartition of energy between each degree of freedom of translation and each effective degree of freedom of rotation. (5) The abnormal behaviour of H at very low temperatures, discovered by Eucken, may conjecturally be accounted for by supposing a change of molecular structure to occur which deprives the H molecule of its two normal degrees of freedom of rotation. If such a change of structure occurs it may be expected to exhibit hysteresis in relation to the temperature. (6) In triatomic and polyatomic gases there are three effective degrees of freedom of rotation which, along with the three degrees of freedom of translation, would make C_v equal to 3R and γ equal to $1\frac{1}{3}$ if there were no energy of vibration. But, in addition, there is in general a considerable amount of energy of vibration, resulting from to-and-fro movements of the atoms within the molecule, to which the principle of equipartition does not apply. Vibrations of relatively long period become important at relatively low temperatures. This makes the specific heat actually greater than 3R and γ less than $1\frac{1}{3}$, especially at high temperatures, when the energy of vibration becomes a large part of the whole energy. (7) It does not appear to be necessary to have recourse to the quantum theory in dealing with molecular rotations in gases; at the same time the observed facts do not conflict with the theory. (8) The general effect of to-and-fro vibrations of atoms within the molecules of a gas is satisfactorily expressed in terms of the quantum theory. The resemblance which exists between the type of curve given by Planck's theory and the curve of magnetisation of a ferromagnetic substance suggests that if the nature of the atoms and their constraints were better understood the results might admit of interpretation in terms which would not be inconsistent with the older dynamics. G. W. DE T.

680. *On Transmission of Mechanical Energy Utilising an Invariable Mass of Gas in a Closed Circuit.* **J. de Lassus.** (Comptes Rendus, 171. pp. 899–901, Nov. 6, 1920.)—Theoretically, methods involving adiabatic compression possess important advantages over isothermal processes, but practically the large temperature variations involved constitute a drawback. The author now proposes to effect the transmission of mechanical energy by utilising a constant mass of gas within a closed circuit. A very full discussion of the method is given and improved power transmission is claimed during changes of speed. H. H. Ho.

681. *Essential Properties of Pneumatic Transmission.* **J. de Lassus.** (Comptes Rendus, 171. pp. 992–995, Nov. 22, 1920.)—A previous communication [see preceding Abs.] contains the general conditions for pneumatic transmission utilising an invariable mass of gas in a closed circuit. The present paper contains a discussion of the principles which regulate the polytropic transformations in the cycle proposed. If V be the coefficient of adiabatic or polytropic transformation, K the volumetric ratio in the two compartments used, M_r and P_r the mass of gas and the reservoir pressure at any instant, M_c and P_c the corresponding terms for the other compartment, P_i the initial pressure, M_{ci} the initial mass in one compartment and M_{ri} in the other, then it is found that $P_c = aM_c^v$, $P_r = bM_c^v$, where a and b are constants; $P_r^{1/v} + KP_c^{1/v} = (K + 1) P_i^{1/v}$; $\rho = K/K_m$, where ρ = volumetric degree of compression corresponding to a given state K_m; $K = V^{1/(v-1)}K_m/[1 - (V - 1)K_m]^{1/(v-1)}$. H. H. Ho.

682. *Temperature Radiation of Gases.* **M. N. Saha.** (Phil. Mag. 41. pp. 267–278, Feb., 1921.)—Various problems of temperature radiation of gases are discussed, particular attention being paid to the bearing of the ionisation potential on the subject. The outlines are given of a hypothesis which is in good general agreement with the observed facts. [See Abs. 157 (1912).] A. W.

683. *Thermodynamics of Radiation.* **H. Klewe.** (Zeits. f. Physik, 3. 2. pp. 104–108, 1920. Extract of Dissertation, Berlin.)—A mathematical

V.2
192

discussion of the effect of an isothermal change of volume of monochromatic radiation. The paper is mainly mathematical and cannot be usefully abstracted. J. W. T. W.

684. *Dynamic Quantum Weight, Nernst Theorem, and Gibbs' Paradox.* **W. Schottky.** (Phys. Zeits. 22. pp. 1–11, Jan. 1, 1921.)—The investigations of Einstein [see Abs. 1710 (1915)], Sterns, and Herzfeld have established the following connection between the Nernst theorem and the quantum theory: For different states of a system whose material composition is given, the temperature coefficients of the free energy at the absolute zero are only identical when the weights of the lowest quantum states for these different substances are the same. The author now investigates the influence of difference in the dynamic quantum weight of solid bodies and gas molecules upon the chemical constant in vapour-pressure and reaction equilibria. First the influence of weight numbers upon the chemical equilibria of systems with many and few components is considered, then the exact dependence of the chemical constants on the quantum weights. Following this comes the discussion of monatomic gases and the lowest quantum state, and then of the higher quanta states of monatomic gas molecules. Polyatomic molecules next receive attention, and speculations are considered with respect to the weight of the quantum state, followed by that of the solid body at the absolute zero. The quantum weight of gas molecules, the unattainability of the absolute zero point, and the Gibbs' paradox are finally investigated. From the theoretical and experimental data the weight appears to be that of the lowest quantum state, thereby affording confirmation of the Nernst theorem. Certain decisive results, however, are still lacking for the classification of this problem. The Nernst theorem cannot be extended to the higher quanta states of mono- and poly-atomic gas molecules, since here dynamic quantum weights occur which certainly differ from unity. A consideration of such cases from the standpoint of the Gibbs' mixture paradox shows immediately that this paradox has its root in the cell structure of the phase space given by the quantum theory. H. H. Ho.

685. *The Problem of the Equation of State.* **L. Schames.** (Zeits. f. Physik, 3. 4. pp. 255–261, 1920.)—The problem of the equation of state is to express the constants in the van der Waals equation, $(p + a/v^2)(v - b) = RT$, as functions of the state, *i.e.*, of v and T. The difficulty which arises is that neither a nor b has been rigidly defined thermodynamically. The author now derives an equation of state in the form $(p + a/v^2)v = RT\phi_{(v)}$ on purely thermodynamic grounds, in which a is defined thermodynamically by $a = T\int[T, \ T = \infty]\, A \,.\, d(1/T)_v$ where $A = -v^2\partial(p/T)_v/\partial \,.\, 1/T$. It appears empirically that for $\phi_{(v)}$ the van der Waals value of $v/(v - b)$ may be substituted; b appears to possess the same value $\sim 1/5$ expressed in reduced units for all substances. The equation of state leads therefore for $p = \infty$ to the limiting volume, $\lim[p = \infty]\, v = b$. For $T = 0$, $p = 0$ does not lead, as previously concluded, to the same value for the limiting volume, which remains undetermined. In contrast to b, the volume and temperature function a is different for different substances, and conditions, therefore, the deviations from the correspondence law. This difference is due to the varying kinds of electrical constitutions for atoms and molecules. H. H. Ho.

SOUND.

686. *The Maintenance of a Vibrating System by Means of a Triode Valve.* **S. Butterworth.** (Phys. Soc., Proc. 32. pp. 345–360; Disc., 360, Aug. 15, 1920.)—This paper gives a mathematical analysis of the arrangement, previously described by Eccles, whereby the vibrations of a tuning-fork are maintained by means of a triode.

In the simplest case, the prongs of the fork vibrate in the field of a permanent magnet, on the pole-pieces of which are wound coils connected in the grid and anode circuits of the valve respectively. From a consideration of the energy relations of the system, it is shown that for the maintenance of oscillations (*a*) the grid and anode coils must be wound in opposite directions, (*b*) there is a certain minimum value of the slope of the grid voltage–anode current characteristic of the valve at its working point.

Following this, the case in which condensers are connected across the two coils is treated on the principle of replacing the dynamical system by its electrical equivalent. In the particular example of similar anode and grid circuits, this system gives rise to three possible oscillations, one with the coils similarly wound and two with the coils oppositely wound. The conditions for maintenance are worked out, and the variation of the obtained frequency in the neighbourhood of the natural frequencies of both the dynamical and electrical systems is illustrated diagrammatically.

Finally, the case in which only one condenser is used is analysed, and a table is given showing the condition of maintenance and the oscillating frequency in the three typical examples. AUTHOR.

687. *Acoustic Method of Measuring Air Velocities.* **W. Kunze.** (Phys. Zeits. 21. pp. 437–443, Aug. 15, 1920.)—The accurate perception of the direction of a sound depends, according to Hombostel and Wertheimer, on the ability of the ear to appreciate the small time interval which elapses between the arrival of a sound-wave at the two ears. The perception of direction depends, according to a definite law, on the extent of this time interval. Now if the angle from which the sound is coming be known, it is easy to calculate the time interval, and in this way it has been found that time intervals of 3×10^{-5} sec. give a measurable effect. This forms the basis of a measurement of very short time intervals and is used by the author for the measurement of the velocity of a stream of gas or of a moving body. A sound-wave is started from a point which is equidistant from two observers. Owing to the velocity of the intervening medium, it reaches them with a short time interval between the two stations. By angle measurement the value of this interval is deduced, and hence the velocity of the medium is found. J. W. T. W.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

688. *The Dielectric Displacement of a Permanent Electret.* **M. Eguchi.** (Phys. Math. Soc. Japan, Proc. 3. pp. 2–4, Jan., 1921.)—In continuation of research on electrets [see Abs. 1329 (1920)] the author uses a condensing electroscope method with a gold-leaf electroscope to measure the dielectric displacement (D) of an internally electrified dielectric cake, and he obtains values for D of from 4·27 e.s. unit to 5·91 e.s. unit. The condensing plate was applied in turn to both surfaces of the cake.

P. E. S.

689. *An Inference from the Fundamental Electromagnetic Equations of the Gravitational Field.* **R. Schachenmeier.** (Zeits. f. Physik, 3. 2. pp. 117–122, 1920.)—The fundamental electromagnetic equations valid in the gravitational field were established by Einstein [see Abs. 853 (1916)]. The present author now shows that for certain cases the equations may be expressed in a form identical with that of the Maxwell equations for crystals with anisotropic dielectric constants. Section 1 deals with gravitational field and dielectric constant. In Section 2 the part of the gravitational potential of calcspar in its dielectric constants is derived, but only a viewpoint is expressed with respect to the actual relationships.

H. H. Ho.

690. *Transformation of Electrodynamic Equations in Maxwell and in Einstein Forms.* **H. F. Baker.** (Cambridge Phil. Soc., Proc. 20. pp. 166–180, Sept., 1920.)—In a preliminary paragraph the author recalls the familiar fact that the complex numbers of ordinary analysis are couplets of two real numbers (x, y) subject to the three laws: (1) if m be a real number, $m(x, y) = (mx, my)$, (2) $(x, y) + (x', y') = (x + x', y + y')$, (3) $(x, y)(x', y') = (xx' - yy', xy' + x'y)$, leading up to a short introduction to the use of matrices, illustrated by the derivation of binary matrices constituting units satisfying the laws of Hamilton's quaternions and quaternary matrices satisfying the laws of combination of the symbols o, i, j, k in W. J. Johnston's symbolic calculus [Abs. 418 (1920)], showing that these non-commutative "imaginaries" may be interpreted, in the same way as the ordinary complex numbers, as aggregates of real numbers. Starting from this interpretation, Maxwell's electrodynamic equations are obtained in a form from which the ordinary Lorentz transformation becomes immediately obvious. The exhibition of Maxwell's equations in this form is seen to be equivalent to their solution in terms of arbitrary functions. An extension of the same method is applied to the equations given by T. de Donder [Archives Musée Teyler, 3. pp. 80–179, 1917] as the electrodynamic equations in the Einstein field, namely, writing ξ, η, ζ, τ for $\partial/\partial x \ldots \partial/\partial t$ respectively, $-\eta M_{34} + \zeta M_{24} = \tau M_{23} = \rho V_z$, $\xi M_{34} - \zeta M_{14} - \tau M_{31} = \rho V_y$, $-\xi M_{24} + \eta M_{14} - \tau M_{12} = \rho V_z$, $\xi M_{23} + \eta M_{31} + \zeta M_{12} = \rho$, $-\eta N_{34} + \zeta N_{24} - \tau N_{23} = 0$, $\xi N_{34} - \zeta N_{14} - \tau N_{31} = 0$,

$-\xi N_{24} + \eta N_{14} - \tau N_{12} = 0$, $\xi N_{23} + \eta N_{31} + \zeta N_{12} = 0$. Here, instead of one system of two sets each of three quantities (X, Y, Z), (L, M, N), which interchange, we have two systems each of six, connected together in a manner explained in the present paper, with coefficients which are quadratic functions of the coefficients in a certain absolute quadric. De Donder bases his work, following Hargreaves [*ibid.*, 21. Aug. 25, 1908], upon the transformation of differential (integral) forms, which he compounds together by rules which, the present author considers, "appear to have a certain artificiality." The author, by means of the theory of matrices and the use of Grassmann's alternate numbers, shows that any transformation of x, y, z, t, which leaves a certain differential form unaltered, and appropriate corresponding transformations of the elements M_{ij}, N_{ij} of the two systems, and of V_x, V_y, V_z, ρ, the equations change into others of the same form. The demonstration is very much shorter than that given by de Donder, in addition to its being more direct, and it has the advantage of bringing out the identity of much of the algebra with what is familiar in other work. The natural interpretations suggested in the course of the author's demonstration are in accordance with the view which regards the V's as velocity components. The Maxwell equations are a particular case of de Donder's more general ones, the differential form in their case being simply $-(dx^2+dy^2+dz^2+dt^2)$, so that, as the author remarks in a note, Grassmann's units might have been employed in the earlier part of the paper in place of the Johnston units. G. W. de T.

691. *Potentials of Moving Electric Charges.* **A. Anderson.** (Phil. Mag. 40. pp. 228–232, Aug., 1920.)—Let $\phi(t)$, $\psi(t)$, $\chi(t)$ be coordinates of an electron which is at point Q at time t and at point Q′ at time $t - r/c$, where P is any point, $r = Q'P$ and c is the speed of light; then the coordinates of Q′ are $\phi(t - r/c) = \phi$, say, etc., and the speed components of Q′ are ϕ', ψ', χ'. It is then shown that, where $\xi = [\phi'(x-\phi) + \psi'(y-\psi) + \chi'(z-\chi)]/c$, $A \equiv 1/(r-\zeta)$ satisfies the equation of wave propagation, $\nabla^2 A - 1/c^2 . \partial^2 A/\partial t^2 = 0$, or $\Box A = 0$. Then by expressing the condition that, if A be any function of x, y, z, t that satisfies $\Box A = 0$, and F any other function of x, y, z, t, AF shall also satisfy it, it is shown that $F(t - r/c)/(r-\xi)$ will satisfy it. Hence, if the coordinates of Q′ are x', y', z', its speeds u_x, u_y, u_z, its accelerations f_x, f_y, f_z; u_r the velocity component of Q′ along Q′P, and $r(1 - u_r/c) = U_r$; x'/U_r, u_x/U_r, f_x/U_r, etc., will also satisfy the wave-propagation equation at any point P at a distance r from Q′. Then, given a distribution of moving electricity, solutions of the equations of wave propagation that will hold at P can be found as follows: If $A = \int\int\int \rho\, dx'dy'dz'/U_r$, then $\Box A$ will vanish where there is no electricity. If at P there is electricity moving with speed u, A and $\partial^2 A/\partial t^2$, contributed by charges within small sphere with P as centre, vanish with the radius, but $\nabla^2 A$ approaches the value $-2\pi\rho c/u . \log(c+u)/(c-u)$. Hence $A = \int\int\int \rho\, dx'dy'dz'/2\pi U$ is the solution of $\Box A = -\rho uc/u . \log(c+u)/(c-u)$. But u being a function of $t - r/c$, $A = \int\int\int \rho u\, dx'dy'dz'/2\pi c \log(c+u)/(c-u)$. U is the solution of $\Box A = -\rho$, so that the solution of $\Box A = -\rho u_x/c$ is $A = \int\int\int \rho u u_x\, dx'dy'dz'/2\pi c^2 \log(c+u)/(c-u) . U$. This and the corresponding solutions of $\Box A = -\rho u_y/c$, and $\Box A = -\rho u_z/c$, are the scalar potential and the components of the vector potential at P. Thus for a single moving charge e at Q the scalar potential at P is

$eu/2\pi c\mathrm{U} \log (c + u)/(c - u)$, and the components of the vector potential are $euu_x/2\pi c^2\mathrm{U} \log (c + u)/(c - u)$ etc. If the square of u/c is neglected, the expressions become those of Lienard and Wiechert. G. W. DE T.

692. *The Electron Theory of the Metallic State.* **G. Borelius.** (Phil. Mag. 40. pp. 746-763, Dec., 1920.)—This is a summary of the results of the author's modified electron theory of metals [Abs. 335, 336, 948 (1919)] whereby it is sought to explain the various phenomena of thermo-electricity, thermal and electric conduction, and galvanomagnetic phenomena, on the supposition that the metal may be regarded as a simple space-lattice structure of the type NaCl with positive atomic ions at the corners and centres of each face of the cube and an equal number of electrons between them. L. L.

693. *Conditions of Equilibrium for Electromagnetic Matter.* **W. Schottky.** (Phys. Zeits. 21. pp. 232-241, May 1, 1920.)—The success of the Rutherford-Bohr atomic model led the author to investigate the question of the equilibrium of a system built up of material particles—*e.g.*, the positive and negative electrons—subject to no external forces, but in a kind of kinematic equilibrium in which the electromagnetic forces arising from mutual interactions, including the effects of fields of radiation, would be balanced ultimately by inertial reactions such as centrifugal force. For such a system he establishes, in the first place, the equations $2\mathrm{L} = -\mathrm{E}$ and $\mathrm{L} = \mathrm{U}_0 - \mathrm{U}$, where L is the internal kinetic energy of the system, E the electromagnetic energy, U the total energy, and U_0 the value of U when all the masses are at rest with each at an infinite distance from all the others, or, as the author expresses it, in the condition of complete dissipation. If relativity were taken into account, its effect would be to multiply the coefficient of L by a factor slightly less than unity, but as the velocities in view are those of the interior particles of material bodies, its effect would be quite insensible. General energetic considerations then lead to the establishment of the following propositions, in which a K-system is a material system which in the absence of external forces remains in kinetic equilibrium:—(1) If a K-system U is increased by $\Delta\mathrm{U}$ without loss of the K-property, then E increases by $2\Delta\mathrm{U}$ and L decreases by $\Delta\mathrm{U}$; (2) if a K-system be subdivided into parts, each of which is a K-system, L (for the whole) will decrease by the energy of separation, while E simultaneously increases by double that amount. The internal energy of a K-system decreases as the temperature increases, having its maximum value at the absolute zero. Two further propositions deal with the effects of applying external forces to K-systems, one of which shows that in a heated gas enclosed under pressure within rigid walls there will be a sensible transformation of potential into kinetic energy, which accounts for the apparently obvious discrepancy between (3) and the ordinary interpretation of the observed results. The author observes that the dumb-bell atomic model—*e.g.*, of the H_2 molecule—is subject to the basic objection that from the point of view of (1) there can be, in an electromagnetic kinematic model, no undisturbed superposition of rotational and other kind of intramolecular energy. It is shown that, in order that the kinetic energy of a K-system may increase together with the total energy, the law of action between two particles expressed in terms of the distance between them must include only exponents between the limits 1 and 3. G. W. DE T.

694. *Electrical Inertia: a Criticism.* **R. Gans.** (Ann. d. Physik, 62. 4. pp. 323–326, June 17, 1920.)—P. de Heen has claimed to have observed the inertia of electricity flowing through a wire [Mem. de la Soc. Royale des Sciences de Liège (3) 6. 1905]. The author, after pointing out the improbability of an effect so keenly sought for in vain and by very sensitive methods, being discovered with the rough apparatus and superficial methods employed by de Heen, shows conclusively by a detailed examination that the effect observed was due to disturbing effects which he had neglected to eliminate. G. W. DE T.

695. *The Electrical Charges of Atoms and Ions.* **F. Sanford.** (Stanford Univ. California, Publ. [130 pp.], 1919.)—This monograph is too lengthy to be dealt with fully in an abstract. The subject is considered under the following main headings:—Electrolytic dissociation and the charges of ions; Positive atomic charges and radiation; Characteristic charges of metals in the solid state; Electrical charge of the earth; Characteristic charges and specific inductive capacity of metals; Theoretical considerations. The first main head is itself split up into 26 sub-headings; the second into five; and the sixth into two. It will thus be seen how comprehensive is the treatment. The author's fundamental assumptions are based upon the following postulates, by which it is claimed that all known electrical phenomena with the exception of electromagnetism can be explained:—(1) An elastic ether, pervading all known space, passing between and perhaps through the atoms and molecules of all bodies, its electrical elasticity being less between the atoms and molecules of bodies than in free space. From the transverse character of light waves and electric waves in the ether, we regard its elasticity as analogous to rigidity in material bodies. We have no data upon its compressional elasticity, but it is generally regarded as very great. (2) We have electrons which, whatever their nature, act as centres of strain in this medium, and on this account, and by virtue of the elastic reaction of the ether to this strain, repel each other. When in the free ether and at a distance from material bodies they appear to have perfect freedom of movement. (3) We have the earth containing a sufficient number of electrons, both combined and free, to produce a field of great ether strain around it. (4) We have the atoms of material bodies, which also contain electrons, but which seem to contain particles of a substance different from electricity. Since the atomic mass seems to be determined chiefly by this part of the atom, and since mass is the one unchanging characteristic of material bodies, these particles may be called the material sub-atoms. We also know that each of these material sub-atoms requires a different number of electrons to bring its electrical pressure up to the normal pressure in the ether of the earth's field (*i.e.*, to neutralise its positive charge), hence that it has a *characteristic positive charge*, and that the greater this characteristic positive charge the less the electric elasticity of the adjacent ether. (5) It is known from experiment that the electric stress around a charged spherical conductor falls off with the square of the distance from the centre of the sphere. This being true, the ether stress about a sphere as large as the earth would be of nearly the same intensity on all sides of a small body. That is, the pressure upon an electric charge in the earth's field is nearly of the nature of a hydrostatic pressure.

Reference is made to a previous publication of the author, entitled "A Physical Theory of Electrification" (*ibid.*, 1911). L. H. W.

696. *The Connection between the Maxwell Equations for Dielectrics and the Atomic Hypotheses of H. A. Lorentz.* **H. Faxen.** (Zeits. f. Physik, 2. 3. pp. 218–229, 1920.)—Maxwell's fundamental equations for the electro-optical phenomena of dielectrics are first recorded and then Lorentz's integral equation based on atomistic grounds and on the assumption that the phenomena are pure harmonic functions of the time. The object of the present paper, which is mathematical throughout, is to show the connection between the two hypotheses, and to prove that Oseen's result is a logical consequence therefrom. H. H. Ho.

697. *Lagrangian Methods for High-Speed Motion.* **C. G. Darwin.** (Cambridge Phil. Soc., Proc. 20. pp. 56–60, Sept., 1920.)—This consists essentially of the fundamental analysis in condensed form of the author's paper on the Dynamical Motions of Charged Particles [Abs. 1312 (1920)]. G. W. de T.

698. *Vertical Electric Currents and the Relation between Terrestrial Magnetism and Atmospheric Electricity.* **L. A. Bauer.** (Terrest. Magn. 25. pp. 145–162, Dec., 1920. Presented before the Am. Phys. Soc., Chicago, Dec., 1920.)—One of the outstanding problems of terrestrial magnetism is to determine to what extent the earth's magnetic field can be referred to a potential [see Abs. 729 (1921)]. Electric currents circulating parallel to the earth's surface give rise to magnetic forces which may be represented by a potential, while vertical electric currents produce a magnetic field which cannot be so referred. The test of the existence of a potential is the vanishing of the line integral of the magnetic force round a closed curve on the earth's surface, while if the integral does not vanish then its magnitude and sign provide a means of determining the vertical electric current entering the area enclosed by the curve. A history is given of attempts which have been made from time to time to analyse the earth's magnetic field, in all of which the vertical electric currents deduced from line integrals have come out some thousands of times greater than the values indicated by the usual atmospheric-electric measurements. The present paper contains preliminary results based on the declination chart for 1917 of the British Admiralty and the declination and horizontal-intensity charts for 1920 of the United States Hydrographic Office, thus being based on data far superior to any previously available. The circuits chosen are parallels of latitudes so that the line integrals yield the mean resultant vertical current-density for various zones bounded by parallels, taken 5° apart. These are tabulated, and the general result is that in the higher latitudes upward positive currents, or earth–air currents, predominate, while in the lower latitudes, on the average, downward positive currents prevail. Combining narrow zones there results :—

Zone.	Average Resultant Current-density in Amp./km.^{2}.
North Pole to 45° N.	$+ 26 \times 10^{-3}$
45° N. to 45° S.	$- 10 \times 10^{-3}$
45° S. to South Pole	$+ 21 \times 10^{-3}$

Thus, on the average, negative electricity appears to stream into the earth in polar regions and out into the air in lower latitudes. These results are for complete zones. An inquiry into the distribution of upward and downward currents, by taking line integrals round all 10°

quadrilaterals lying between parallels 60° N. and 60° S. yielded as a preliminary result that, on the average, the positive current is upward over ocean quadrilaterals and those of low pressure and downward over land and high pressure, but the separate effects of land and sea, pressure and latitude, have not yet been disentangled. The vertical current has been computed for the United States from the 1915 magnetic charts of the United States, with a result agreeing well with that previously obtained from 1905 charts. The average current-density over the greater part of the United States appears to be downward positive of amount 31×10^{-3} amp./km.^{2}. These latest results still show vertical currents i_m, deduced from line integrals of magnetic forces, many times larger than values i_a obtained from atmospheric-electric measurements. In fact, on an average, approximately $i_m = 10^4 \times i_a$. Further, atmospheric-electric results indicate that all over the earth the vertical current is, under normal conditions, downward positive, whereas the above results suggest the direction is different in low and high latitudes. The two sets of results have yet to be reconciled, and there is need, in particular, of determining unquestionably the direction of the air-earth current during normal weather in all parts of the earth. M. A. G.

699. *Determination of Charges on Fog Particles: a Contribution to the Problem of the Existence of the Electrical Quantum Element.* **E. Radel.** (Zeits. f. Physik, 3. 2. pp. 63–88, and pp. 422–424, 1920.)—The methods first employed by Ehrenhaft [see Abs. 411 (1910)] and Millikan for measuring the electrical quantum element are based on the velocity with which a fog of small drops falls under gravity in a plate condenser and rises again in an electrical field. The results by different observers vary so appreciably from each other that the present author has again re-opened the question. The experimental arrangements are very fully described, and follow Ehrenhaft's ultramicroscopic method for the estimation of charges on fog particles. The latter were prepared from paraffin oil, colophony, mercury, and gold. The results were as follows:—(1) Using the Stokes-Cunningham law (A = 0·815, complete inelastic reflection of the gas molecules), a value was only found in the interval $(10–80) \times 10^{-6}$ cm. for paraffin oil, mercury, and colophony, which approximated to that calculated by Millikan, namely, $4 \cdot 77 \times 10^{-10}$. (2) For mercury particles, whose radii lie below 10×10^{-6} cm. according to the resistance law, and for gold below 27×10^{-6} cm., the resulting charges became smaller with decreasing radius, and fall considerably below $4 \cdot 77 \times 10^{-10}$. By means of charge alterations, produced on these particles by ionisation with a radium preparation, the apparent subquanta assumed values which again possessed ratios of very small whole numbers. (3) The application of the formula of Einstein and Weiss to the theory of molecular motion, in which density and particle radius do not enter, gave values for these particle charges which, although affected by considerable fluctuations, group themselves about the correct value of the electrical quantum element, without showing any tendency to a systematic falling below this magnitude. (4) From a calculation of the average square of the displacement it is shown that particles mentioned in (2), which give smaller charges, have too small mobilities when the radii claculated according to the resistance law are assumed to be correct, while particles giving the correct *e*-values also afford the corresponding average displacement-square given by theory. The particles possessing apparent subquanta are distinguished accordingly from those with correct elementary charge with respect to a magnitude which is completely independent of the state of charge. (5) The experiments unfortunately do not afford a satisfactory explanation for the deviations from the electronic value. It is established under (4), however, that the subquanta measured have nor eal existence. H. H. Ho.

DISCHARGE AND OSCILLATIONS.

700. *Equilibrium Conditions for Electron Emission from Glowing Bodies.* **M. v. Laue.** (Jahrb. d. drahtl. Tele. 16. pp. 199–218, Sept., 1920.)—The differential equation for the steady state is first obtained and solutions are given for the cases of (1) a plane anode with a plane incandescent kathode; (2) an incandescent cylinder with an axially symmetric electric field. The discussion is based on statical considerations. [See Abs. 604 and 1421 (1919).] A. W.

701. *Collisions Between Atoms and Free Electrons.* **O. Klein** and **S. Rosseland.** (Zeits. f. Physik, 4. 1. pp. 46–51, 1921.)—The experiments of Franck and Hertz [Abs. 752 (1919)] on ionisation and radiation by the collisions of slow electrons with gaseous atoms or molecules show that the collision between an atomic system and a free electron may, under certain conditions, cause the system to pass, without radiation, from the normal state of least energy to a stationary state of greater energy, while the electron, after leaving the sphere of action of the atom, loses an amount of energy and undergoes a diminution in its velocity corresponding to the energy difference between the second and the first state of the system. Such collisions can only occur when the energy of the free electron is greater than that energy difference. The consequence would apparently be a disturbance of the temperature equilibrium of a mixture of atomic systems and free electrons, since some atoms would temporarily acquire higher energy, whilst the electrons lose energy. That would contradict the second law; the transitions must be compensated for by the free electrons themselves so soon as their velocities are distributed according to the temperature equilibrium. It has to be deduced from Franck and Hertz's experiments, then, that such collisions can also occur between free electrons and atoms in which the atom hit passes, without emitting radiation, from a stationary state of greater energy into a stationary state of smaller energy, whilst the hitting electron acquires an amount of kinetic energy equal to the energy lost by the atom. The authors consider such collisions of the "second order," calling those of Franck and Hertz collisions of the first order; both types of collisions would be compatible with Bohr's postulate that two colliding systems must, before and after the collision, be in mechanically definable states. Formulæ for the probabilities of the two collisions are deduced. H. B.

702. *Excitation of Light by Kathode Rays in Air.* **G. S. Fulcher.** (Astrophys. J. 52. pp. 278–285, Dec., 1920.)—A beam of kathode rays, after passing through a hole in the anode of the discharge tube in which the rays were produced, was placed at the focus of the collimating lens of a spectrograph and the *intensity of the nitrogen bands* excited was determined for various discharge potentials and for various distances apart of the electrodes. The results show that, unlike canal rays, kathode rays in passing through nitrogen excite less light per collision the greater their energy, at least *for the range of speeds corresponding to from* 1500 *to* 3500 *volts*. Since the rays used were not homogeneous, the exact law of variation cannot be determined from the data obtained, but the results indicate that the light per collision varies inversely as a power of the speed somewhat less than the second; and it is pointed out that if, as is quite possible, the light intensity per collision varies with the speed in the same way as the chance of ionisation per collision, then the light intensity per ionising collision is independent of the speed. AUTHOR.

703. *Equipotential Surfaces of Kathode Rays under the Influence of Opposing Longitudinal Electric Fields.* **W. Loest.** (Zeits. f. Physik, 3. 2. pp. 130–140, 1920. Extract of Dissertation, Berlin.)—E. Gehrcke and R. Seeliger have found [see Abs. 908 (1912)] that under suitable conditions a kathode ray by alteration of its velocity shows colour and intensity alterations. In the present paper is given the course of the potential and surface levels of the kathode rays which are distorted by means of longitudinal electrical fields. From the equipotential surfaces it is shown that at the apex of the parabola and with an incidence of 90° to the ray-point free negative space-charges appear. It was also shown with the same arrangement that the form built up by the opposing field always acts as kathode in an independent discharge. It is impossible to avoid completely this kathode action. The sound measurements also prove that the field potential in volts and the electron-velocity of the displaced kathode rays in volts are not always to be taken as identical. It appears that this method of displaced kathode rays is little suited to quantitative explanation of the question. A. E. G.

704. *On Migration Velocity and Molisation of Complex Electrical Carriers in Flame Gases.* **F. Lauster.** (Zeits. f. Physik, 3. 5. pp. 396–403, 1920. Extract of Dissertation, Frankfort.)—The process of ionisation consists of two phases, ionisation and molisation, which are in equilibrium, this state being characterised at any instant by a carrier concentration which finds expression in the ionisation current. From the finite productivity of the carrier source, it is manifest that this current approaches a finite saturation value with increasing potential difference of the electric field. The existence of this saturation current, and the regular course of the molisation finds its mathematical treatment in the Thomson theory. The experimental proof of this regularity has been established for almost all the known ionisations. McClelland's work on the conductivity of hot flames also shows the existence of a saturation current and the validity of the molisation law. In the present paper three further examples are investigated, namely: (1) By the use of small flames of not more than 1 cm. high, whereby the influence of the flame upon the flame-gas temperature is eliminated as far as possible, McClelland's previous investigation of the relationship between carrier mobility and flame-gas temperature has been thoroughly explored. The results appear to furnish an explanation of the complex character of the electrical carriers, and so afford further support to the cluster theory. (2) Investigations as to the simultaneous presence of several species of carriers have been made, and the possibility of the superposition of saturation curves established. Data have been acquired with respect to the electrical phenomena of phosphorus oxidation as described by Harms, and the validity of Schmidt's objections has been confirmed. (3) Notwithstanding the small carrier concentration, the law of molisation has been re-affirmed and the re-union constant a/e determined. This varies from 700 to 2500, according to the temperature. Section 2 of the paper describes the methods employed, and Section 3 deals with the experimental arrangements. The critical temperatures of complex carrier decomposition have been determined for the flames of carbon monoxide, ordinary illuminating gas, and hydrogen. It appears that with increasing production of water-vapour the critical temperature rises, accompanied by an increase in carrier size. At the cluster formation solid combustion products are still formed in addition to water molecules. The ionisation current exhibits an exponential rise with the temperature of the flame gases. Curves and diagrams are included. H. H. Ho.

705. *Ionisation and Excitation of Radiation by Electron Impact in Helium.* **F. S. Goucher.** (Phys. Soc., Proc. 33. pp. 13–29; Disc., 29–31, Dec., 1920.)—Measurements have been made of the critical potentials for helium by the method used in the experiments of Davis and Goucher, and compared with the ionising potential of mercury vapour taken as a standard. Assuming the ionising potential of mercury to be 10·4 volts, two critical potentials occur in helium, one at about 20 volts and the other at about 26 volts. These critical values agree well with those obtained by Horton and Davies.

The effect of radiation alone on the metal parts of the apparatus was studied under conditions which would yield evidence of use in the interpretation of the results obtained when the production of both ionisation and radiation was taking place simultaneously.

Conclusion.—The conclusion is reached that the lower critical potential is a radiation potential, though some ionisation is produced also at this potential. This, however, is attributed to the presence of impurity, probably hydrogen. The higher critical potential was that at which ionisation took place. AUTHOR.

706. *Radiating and Ionising Potentials of Hydrogen.* **K. T. Compton** and **P. S. Olmstead.** (Phys. Rev. 17. pp. 45–53, Jan., 1921.)—To detect and distinguish between radiation and ionisation, the Lenard method, modified by the introduction of a receiving electrode of variable area, was used. Both radiation and ionisation were obtained at about 10·8 volts, probable radiation at about 13·4 volts, and strong ionisation at 15·9 volts. These *experimental results* are compared with those of other investigators; and as an *explanation of apparent discrepancies* it is pointed out that the following effects may occur together: radiation from free atoms near 10·8 volts and ionisation near 13·5 volts, ionisation without dissociation of molecules near 10·8 volts, dissociation plus radiation from one of the atoms near 13·4 volts, and dissociation plus ionisation of one atom near 15·9 volts. AUTHORS.

707. *Calculation of the Amplification Constant of the Weagant Thermionic Vacuum Tube.* **A. Marcus.** (Phys. Rev. 17. pp. 1–6, Jan., 1921.) —This tube has the control electrode on the outside, and because of the presence of the glass wall amplification is not possible for constant grid potentials. By making some simplifying assumptions, the author is able to develop a *theoretical expression* for the amplification constant which involves the dimensions of the tube and the resistivity of the glass wall. When this resistivity is either very high or very low, the amplification is small; in the latter case it is shown to depend solely on the dimensions. AUTHOR.

708. *Pressure on the Poles of an Electric Arc.* **A. M. Tyndall.** (Phil. Mag. 40. pp. 780–781, Dec., 1920.)—The author objects to some remarks by Ratner [Abs. 300 (1921)], because in the work quoted (1) the vane, upon which a pressure due to the electric wind was detected, was placed behind a perforated electrode, and therefore received momentum from the wind passing through the perforations without the compensating attraction of the ions of the discharge. The statement that those experiments give evidence of a repulsion of an electrode which has an opposite sign to the ions giving rise to the wind is therefore incorrect; (2) in remarking on the diminution of wind with high values of the current the fact is ignored that an electric current in a gas is not, in general, carried by one sign of ion only. In a discharge from a point at atmospheric pressure, with small values of current, only one sign of ion is present throughout the greater part of the path of the discharge; this is, however, not true for all values of current and pressure, and it is very improbable that it is true for any values in the arc discharge. The author quotes his work, in conjunction with H. E. G. Beer, on the electric wind in the arc. It is in general found to be exceedingly minute, and in the direction from kathode to anode. The results are consistent with the view that the effect is a residual one, being the difference between the effects of the positive and negative ionic streams. Owing to the great difference between the specific mobilities of positive and negative ions at arc temperatures, it is only necessary to assume that through the body of the arc less than ½ % of the total current is carried by the positive ions, in order to account for the observed wind. T. H.

709. *Note upon the Alternating-Current Arc.* **W. G. Duffield** and **M[ary] D. Waller.** (Phil. Mag. 40. pp. 781–785, Dec., 1920.)—It has been shown [Abs. 100 (1916)] that the amount of carbon lost from the kathode of a d.c. arc consists of two parts: (1) that necessary for the mechanism of the arc; (2) that lost by evaporation or combustion which can be only regarded as subsidiary. With an arc less than 1 mm. in length the loss from the kathode is entirely due to (1). Further [Abs. 365 (1916)], in the normal arc the anode loss is greater than that from the kathode, but by rotating the anode it is possible to cool it so that its loss may be reduced nearly to zero. The shape of the anode of the d.c. arc remains practically unchanged, but the kathode of a very short arc goes through a well-marked cycle of changes, repeated again and again as the expenditure of carbon proceeds. In the present work the a.c. arc is examined as regards these features. The previous method of experiment is adopted, and it is found that the loss from each pole approximates to the mean of the anode and kathode losses in the d.c. arc. In all cases there is subsidiary as well as essential carbon loss. There is no cycle of changes in the shape of the poles, but a contour of unvarying form. For short arcs the lower, and for long arcs the upper pole loses more rapidly, which is, no doubt, due to convection currents having a greater access to the under surface of the upper carbon in a long arc. The argument used in the case of the d.c. arc that the evaporation of carbon is of the wrong order of magnitude to account for the pressure observed on the poles, holds good for the a.c. arc also. The pressure is made up of the reaction consequent upon electron emission during the half-period while the pole is acting as kathode, and the reception of momentum from the other pole during the second half-period when it is acting as anode. T. H.

710. *Electromagnetic Waves in Dielectric Wires.* **O. Schriever.** (Ann. d. Physik, 63. 7. pp. 645–673, Dec. 1, 1920.)—This subject has previously been treated by Hondros and Debye [Abs. 1132 (1910)]. The present paper gives a further theoretical discussion, and describes experiments in verification of the theoretical conclusions. It is shown that by successively increasing the conductivity of the material used for the wire, a gradual change takes place from the "dielectric" waves to those found in metallic wires. A. W.

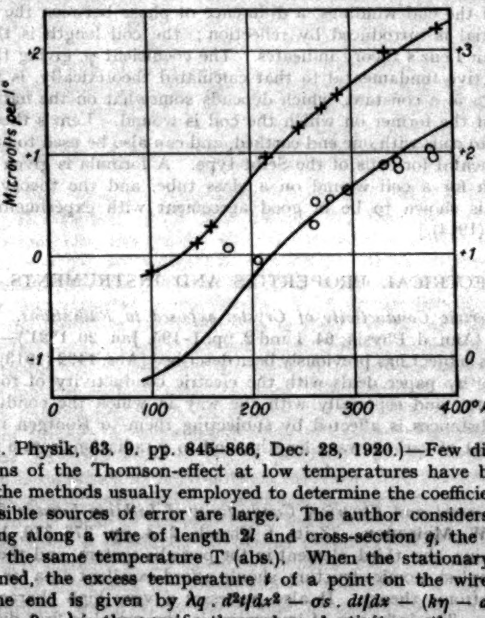
711. *Fundamental and Harmonic Oscillations of Single-layer Coils.* **W. Geiss.** (Ann. d. Physik, 64. 4. pp. 377–400, Feb. 24, 1921. Dissertation, Frankfort.)—Lenz's theory of the fundamental oscillation of open coils gives, within the required limitations, a very close approximation to the proper ratios. The formulæ hold for open coils at whose ends the current and potential remain constant, the self-capacity of the windings being neglected. For open coils with free ends, on account of the capacity of the end windings, a difference of phase between the current and potential is introduced by reflection; the coil length is therefore smaller than Lenz's theory indicates. The coefficient γ, giving the ratio of the effective fundamental to that calculated theoretically, is for long coils ($h/2r > 5$) a constant, which depends somewhat on the nature and thickness of the former on which the coil is wound. Lenz's theory can be applied to coils with one end earthed, and can also be used to calculate the fundamental for coils of the Seibt type. A formula is given for the wave-length for a coil wound on a glass tube, and the theory of the harmonics is shown to be in good agreement with experiment. [See Abs. 1107 (1914).] A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

712. *Electric Conductivity of Crystal exposed to Radiations.* **W. C. Röntgen.** (Ann. d. Physik, 64. 1 and 2. pp. 1–195, Jan. 20, 1921.)—Earlier work on this subject has previously been described [Abs. 1492 (1913)]. The present lengthy paper deals with the electric conductivity of rock-salt, calc-spar, etc., and especially with the way in which the conductivity of these substances is affected by subjecting them to Röntgen rays, to ordinary light of various wave-lengths, and to γ-radiation from a radium salt. A. W.

713. *Thermal and Electrical Conductivity of Lithium between 20° and 373° abs.* **W. Meissner.** (Zeits. f. Physik, 2. 4. pp. 373–379, 1920.)—Lithium, being the third element in the periodic system, and the metal with the simplest atomic structure, should afford excellent data for testing modern electronic theory. It also possesses a very high characteristic temperature. The influence of impurities in the metal is first discussed and the present investigation of thermal and electrical conductivity undertaken upon a specimen of Kahlbaum's lithium. Debye's results, which failed to establish an electronic lattice for lithium, are referred to [see Abs. 497 (1920)]. Experimental arrangements are described at some length, the investigation meeting with special difficulties on account of the instability of lithium in air. Two rods were tested between + 56° and − 193°, and + 100° and − 250° C. respectively, and the results found to agree within the common temperature range. The data are tabulated, and a comparison is made with previous results obtained for copper. The Lorentz law $\lambda/\kappa T$ = const. is found to be invalid between 0° and 100° C., where λ is the thermal conductivity, κ the electrical conductivity, and T the temperature. Below 0°, the value of $\lambda/\kappa T$ deviates more considerably than with metals previously investigated. The value of λ between 0° and 100° is practically constant, but increases below 0° C. A table is included, giving the data of Guntz and Broniewski for the temperature dependence of the resistance of Li between + 100° and − 190° C. According to the observations at − 187°, the Kahlbaum lithium must be regarded as purer than that prepared by Guntz and Broniewski. Abnormal results, however, are found to be unexplained by impurities. H. H. Ho.

714. *Measurement of the Thomson-Effect from the Stationary Thermal Condition in a Wire Conveying an Electric Current.* **G. Borelius.**



(Ann. d. Physik, 63. 9. pp. 845–866, Dec. 28, 1920.)—Few direct determinations of the Thomson-effect at low temperatures have been made, and in the methods usually employed to determine the coefficient directly the possible sources of error are large. The author considers a current s, flowing along a wire of length $2l$ and cross-section q, the ends being kept at the same temperature T (abs.). When the stationary condition is attained, the excess temperature t of a point on the wire distant x from the end is given by $\lambda q \,.\, d^2t/dx^2 - \sigma s \,.\, dt/dx - (k\eta - d\rho/dt \,.\, s^2/q)t + \rho s^2/q = 0$. λ is the specific thermal conductivity, p the specific resistance of the wire, and $k\eta t$ is the heat loss by emission per cm. length. Writing the equation in the form $d^2t/dx^2 - 2a \,.\, dt/dx - b^2t = c$, it is shown that $t = (\rho\sigma^2/2\lambda q)x(2l - x)\phi_1(x, l, b)$, and if 2T be the change in temperature at x on reversal of the current—

$$T = (\sigma\rho s^3/6\lambda^2 q^3)x(2l - x)(l - x)\phi_2(x, l, b).$$

Three possible methods of procedure are then discussed : (1) A method previously used by the author [Abs. 1188 (1918)], where the flow of heat to the ends of the wire was measured. Corrections are now introduced for change of resistance with temperature by this method. (2) The deduction of σ from the relative changes in resistance of the two halves of the wire. The potential change p at the mid-point of the wire is shown to be

$$\frac{\sigma}{3}\,\frac{\rho^2 s^4 l^4}{4\lambda^2 q^4}\,\frac{1}{\rho}\,\frac{d\rho}{dt}.$$

This change is small if the excess temperature of the mid-point is only of the order 10 degrees. (3) The measurement of the ratio T/t at a given point of the wire, either by a thermo-couple or bolometer method. This ratio the author obtains in the form : $T/t = (\sigma s/\lambda q)F(xl)\phi_3(xlb)$. If the external heat loss is small the max. value of T is given by $x = l \pm l/\sqrt{3}$.

The last method has been adopted. It possesses the advantage that only the ratio of two temperature changes is involved, and the variation of λ with temperature is fairly well established. The test wire was of copper, supplied by Max Sievert, of Stockholm, the resistivity showing it to be of a high degree of purity. The length was 21·74 cm., and the sectional area 0·497 mm². The ratio T/t was determined 4·13 cm. from the end, which is approximately near the best position. The wire, current leads, and thermo-couple were mounted on a frame in a partially exhausted glass vessel. This vessel was placed in a vacuum flask, and the ratio determined for temperatures varying from that of liquid air to steam. The upper curve in the Fig. shows the results obtained, the lower curve being plotted from data previously obtained by Berg in 1910. L. L.

715. *The Electric "Dipole" in Liquid Dielectrics; Confirmation of the Theory.* **J. Herweg.** (Phys. Zeits. 21. pp. 572–576, Nov. 1 and 15, 1920. Paper read before the 86. Naturforscherversamml., Nauheim, Sept., 1920. Zeits. f. Physik, 3. 1. pp. 36–47, 1920.)—It is well known that the dielectric constant of many liquid dielectrics (alcohol, ether, etc.) has a large negative temperature coefficient. On the old theories of dielectric phenomena (Clausius, Mosotti) this dependence on temperature cannot be explained. In 1912 Debye suggested the possibility that the phenomenon could be explained by assuming that in addition to the "displacement electrons" in the liquid a complete electric "dipole" existed in the molecules. It then remained to demonstrate the existence of these "dipoles" by means of electric fields. Ratnowsky was the first to show, theoretically and practically, that if this dipole existed, then a change of dielectric constant would be observed if the liquid were placed in a strong electric field. Thus a measurement of the dielectric constant in a weak and in a strong electric field would serve as a test of Debye's theory.

The author now describes an experimental examination of the dielectric constant of amyl alcohol, pure benzol, and ethyl ether, under such conditions. The result of the investigation gives strong support to the theoretical deductions of Ratnowsky and Debye. A. B. W.

716. *Dielectric Constants and Form Numbers of Mixtures of Salt Grains and Air.* **E. Stoecker.** (Zeits. f. Physik, 2. 3. pp. 236–243, 1920.)—The object of this paper is to derive a method for the calculation of the dielectric constants of compact salts from measurements of salt powders, and is a continuation of Wiener's work [see Abs. 150 (1920)]. A number of mixtures of potassium chloride and air were measured, and the results were found to be in good agreement with Wiener's theory. The form numbers u for different forms and sizes of the salt grains were evaluated from the observations, and u was found to increase the more, the greater the deviation of the grains from spherical shape and the closer they were packed. For the unpulverised salt the dielectric constant and form number of the mixture increased with the coarseness of the salt grain. With the finely pulverised salt, the dielectric constant and form number are independent of the size of grain. A table is given of values which are applicable to all pulverised salt powders of regular crystals. For compact salts the form number is approximately 4. H. H. Ho.

717. *Unilateral Conductivity of Tubes having a Salt Electrode.* **M. Kimura** and **J. Nagahata.** (Kyoto Coll. Sci., Mem. 4. pp. 163–165, June, 1920.)—While studying the spectrum of chlorine [Abs. 436 (1921)], it was found that a tube having sodium chloride as one electrode allows an electric current to pass easily in one direction but not in another. With the salt as kathode the discharge at low pressures passed easily, but not when the small platinum electrode was kathode. This effect was investigated, and it was found that maximum rectification was obtained when the quantity of salt was just sufficient to cover the platinum wire sealed through the side tube containing the salt. The salt electrode, when rectifying the current from a ½-kw. transformer, got very hot, and the tube allowed the current to flow only from the colder to the hotter electrode. In this respect the salt electrode seems to behave like a Wehnelt kathode. Similar results were obtained with KCl, $BaCl_2$, etc. A possible explanation of the effect is suggested. A. W.

718. *Rectification at Solid Contacts.* **R. Audubert.** (J. de Physique, 7. pp. 209–223, Nov.–Dec., 1917.)—Describes an investigation of the phenomena of rectification for mixtures of bodies which present in the pure state very different characteristics: silver sulphide and lead sulphide. The latter approximates to the metals, its resistance is great and increases with temperature. Silver sulphide has a much higher resistance and a negative coefficient. Pure materials were mixed together in known proportions and then fused, suphur being added to prevent oxidation. The resulting solid was then used with a metal point to which various small (measured) pressures could be applied. Friedrich found for these substances a single eutectic having about 76 % silver sulphide. The results are presented in a series of curves and tables. It was found that the sensibility passes through a minimum value for a mixture corresponding approximately to the eutectic. Curves are also given showing the effect of variation of the pressure on the contact. The results show that pressure, temperature, and current across the contact all produce the same effects, a cohering action taking place. [See Abs. 2085 (1902).] A. W.

719. *Sensitive Valve Method for the Measurement of Capacity; Applications.* **J. J. Dowling.** (Roy. Dublin Soc., Proc. 16. pp. 175–184, Dec., 1920.)—In its simple form the apparatus used in this method was arranged as follows: One terminal A of an a.c. source was connected directly to the negative end of the filament of a valve, and also through a milliammeter or, preferably, a sensitive galvanometer, to the negative terminal of the anode battery. A was also connected through a resistance of 0·5 megohm to the grid, and thence through the condenser C under test to the other terminal of the a.c. source. The filament battery was shunted by a potentiometer, and a tapping from this was joined through a 10,000-ohm resistance to the negative terminal of the anode battery, the positive terminal of which was joined directly to the anode. If the greater part of the anode current is balanced by the current from the filament battery due to the p.d. across that part of the potentiometer in use, accurate comparison can be made between two condensers of nearly equal capacity introduced at C, or a study can be made of slight variations in a single condenser. With the arrangement described above the relation between galvanometer deflection and capacity is almost linear. Unsteadiness of the galvanometer deflections was eliminated considerably by suitable metallic screening and insulation of the various parts of the apparatus.

An application of the apparatus as an ultra-micrometer and as a micro-pressure gauge is described. A. W.

720. *Self-Inductance of Multi-layer Coils.* **A. Esau.** (Jahrb. d. drahtl. Tele. 15. pp. 2–26, Jan., 1921.)—A formula is derived for the self-inductance of a multi-layer coil in which the distance between the layers is different from that of successive turns in each layer. As special cases of this general formula are considered: (1) Strasser's formula for single-layer cylindrical coils; (2) the author's formula for flat coils; (3) coils with rectangular section and equal winding and layer separation; (4) coils of square section; (5) coils with very close windings. The calculation of the inductance of square and rectangular coils, which frequently occur in practice, is very much simplified by the use of tables given. In the second part of the paper the formulæ of Maxwell, Perry, Weinstein, Stefan, and others for multi-layer coils are compared with the formula here given, and it appears that all show discrepancies which are by no means negligible. If, however, the formulæ are used in conjunction with one of Maxwell's correction formulæ, the differences in many cases become unimportant. So that unless very great accuracy is required, the use of these formulæ with Maxwell's correction formula is quite legitimate. A. W.

721. *Use of Triode Valves in the Laboratory.* **J. Scott-Taggart.** (Electrician, 86. p. 124, Jan. 28, 1921.)—(1) *Measurement of High Voltages.*—A triode valve is connected across the points whose voltage difference is to be measured, a milliammeter A or galvanometer being put in the anode lead. A potentiometer is used to adjust the grid to a negative potential which just prevents the passage of current through the valve. A voltmeter V shunted across the part of the potentiometer in use, *i.e.*, across grid and filament, serves to measure the negative grid potential. The required voltage is then obtained from the reading of V by multiplying by a constant which is rather less than the voltage amplification factor of the valve. For high voltages the valve impedance should be very high and the grid preferably a closely woven wire mesh.

(2) *Testing High Insulation.*—The grid circuit of a valve contains a battery (up to 50 volts) with its positive side connected to the filament. The grid circuit is broken between the negative terminal of this battery and the grid. A milliammeter A is included in the anode circuit. The current through A is first noted. The condenser or other arrangement whose insulation is to be tested is now introduced into the " break " in the grid circuit, and after an interval the reading of A is again noted. If the readings are substantially the same the insulation may be considered infinite. The slightest faultiness would be indicated by an increase in the current through A. The explanation is simple. A. W.

722. *Absolute Electrometer.* **A. Guillet** and **M. Aubert.** (J. de Physique, 7. pp. 223–228, Nov., 1917.)—The authors have previously described an electrometer of the plane-sphere type [Abs. 1556 (1912)]. By substituting a second sphere for the plane surface a bi-spherical electrometer is obtained. The construction of such an apparatus is very simple, but the calculation of the action between the two spheres is laborious. Formulæ are derived for the general case, and an approximate formula is also given. With equal spheres, the distance of their nearest points varying from a tenth of the diameter to four times the diameter, the corrections which must be applied to the ordinary Coulomb formula vary from 0·215 to 0·001. That is, to obtain the true charge or potential, it is necessary to multiply by 1·215 or 1·001 respectively. A. W.

723. *Induction Motor with Large Air-Gap and Rotating Field-Magnets.* **J. K. Roberts.** (Roy. Soc. Victoria, Proc. 32. pp. 156–163, Sept., 1920.)—This paper gives a description of the design of the apparatus used for producing the rotating magnetic field in a new method for the determination of the mechanical equivalent of heat [see Abs. 674 (1921)]. Experiments are described which served to build up the theory and determine the various features of the design. A. W.

724. *New Relay for Moderately Heavy Currents.* **G. Barr.** (Phys. Soc., Proc. 33. pp. 53–56; Disc., 56, Dec., 1920.)—The action of the relay depends on the fact that no arc can be maintained between mercury electrodes in hydrogen. One lead is brought to mercury contained in a vertical tube within a solenoid. An iron rod, at the upper end of which is a glass cup, floats in the mercury. The cup also contains mercury, and the other lead is connected to an iron rod which dips into this. When no current flows in the solenoid, the rim of the cup is about 1 cm. above the level of the main body of mercury. When the relay current (about 0·03 amp.) is running the iron rod is sucked down until the rim of the cup is submerged by about 0·5 cm. The space above the mercury contains hydrogen. The relay can be used to break quite large currents (20 amps.) without much spark. AUTHOR.

ALTERNATING CURRENTS AND MAGNETISM.

725. *The Hall-Effect and the Nernst-Effect in Magnetic Alloys.* **A. W. Smith.** (Phys. Rev. 17. pp. 23–37, Jan., 1921.)—*Hall-Effect in Magnetic Alloys.*—In the *iron-copper series* a maximum effect was obtained with 1·5 % Cu. The variation with composition is very similar to the variation of electric resistance. In the *nickel-copper series* the effect reaches

V.2
192

a maximum with about 26 % Cu, when the composition corresponds to the formula $CuNi_3$, and then drops suddenly to a small fraction of its max. value. In the *iron-nickel series*, although the effect is positive for iron and negative for nickel, the effect increases linearly with the proportion of nickel added to iron until for 13 % Ni it is six times as great as for pure iron. In certain alloys the *variation of the effect with the field strength* is anomalous, the effect being negative for weak fields and positive for strong ones. An *explanation based on the theory of Borelius* is suggested which assumes that in addition to the positive part of the effect which is proportional to the field strength there is a negative part which reaches a limiting value for strong fields.

Nernst-Effect in Magnetic Alloys.—In the *nickel-copper series* the effect varies with composition in nearly the same way as the Hall-effect does, reaching a maximum for the composition $CuNi_3$. In the *iron-nickel series,* the effect decreases with the addition of nickel, becoming zero for about 2·2 % Ni and positive for higher concentrations. With 13 % Ni the effect is about five times as great as in pure iron.

Relation of the Hall- and Nernst-Effects to Crystal Structure.—It is *suggested* that the amount and direction of these effects are determined by the crystal lattices and the fields of force in the intramolecular spaces.

AUTHOR.

726. *Absorption of γ-Rays by Magnetised Iron.* **A. H. Compton.** (Phys. Rev. 17. pp. 38–41, Jan., 1921.)—*Ring Electron Theory of Magnetism; a Deduction Regarding the Absorption of γ-Rays by Iron.*—We should expect a ring electron to absorb more energy if its axis is parallel to a transversing beam of γ-rays than otherwise; therefore, if by magnetisation the axes of the ring electrons are turned so as to be more nearly parallel to the γ-rays, the part of the absorption due to the transfer of energy to such electrons would be increased. The negative result given by the experiment carried out to test this deduction, however, does not disprove the theory, but indicates merely that the absorption due to this cause is small.

Absorption of γ-Rays by Iron.—The effect of magnetisation was to change the absorption by less than 0·03 % whether the magnetic field was parallel or perpendicular to the beam of hard γ-rays used. AUTHOR.

727. *The Molecular Magnetic Field.* **R. Gans.** (Ann. d. Physik, 63. 4. pp. 382–396, Oct. 19, 1920.)—Starting with an elementary magnet, at absolute zero, acted on by the molecular field A, and the externally applied field K, the method of probabilities is applied to calculate the value of M/M_∞, the Langevin ratio, first with uniform distribution of direction of A, and secondly, when the distribution of A corresponding to the saturation is taken. When M/M_∞ is plotted against K/A, for each case, the graphs coincide. Hence it is concluded that at absolute zero all directions of the molecular field may be considered as equally probable for the calculation of the magnetisation curve. This statement holds also for any other temperature. [See also Abs. 1288 (1916).]

G. E. A.

728. *Diamagnetism of Monatomic Gases.* **W. Pauli, Jr.** (Zeits. f. Physik, 2. 3. pp. 201–205, 1920.)—Starting from Larmor's theorem, the author works out an expression for the specific diamagnetism of the atom in terms of its electrical moment of inertia $\sum er^2$. Taking the amended values of Tänzler [Abs. 478 (1908)] and those of Soné [Abs. 624 (1920)] for the susceptibilities of helium and argon, values are obtained for the moment of inertia which, tested by the kinetic theory of gases, are impossible. The observed susceptibilities of He and Ar are at least ten times greater than the values expected from theory. G. E. A.

729. *Some of the Chief Problems in Terrestrial Magnetism and Electricity.* **L. A. Bauer.** (Nat. Acad. Sci., Proc. 6. pp. 572–580, Oct., 1920.)—A general survey of the main problems with indications of the direction in which future progress lies. The chief problems fall under the following: (1) Analysis of the earth's general magnetic field; whether or not the magnetic forces of the earth can be entirely referred to a potential; (2) analysis of continental and regional magnetic fields; (3) effect of altitude upon the earth's magnetic and electric elements; (4) variations in the earth's magnetic and electric phenomena; (5) magnetic storms, polar lights, and earth currents; (6) magnetic and electric observations during solar eclipses; (7) problems of joint interest with physical oceanography; observations over the oceans; (8) problems of joint interest with volcanology; (9) laboratory problems. M. A. G.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

730. *Abnormal Indications Furnished by Radiochromometers with very Penetrating X-rays.* **R. Biquard.** (Comptes Rendus, 171. pp. 907–909, Nov. 8, 1920. Arch. d'Él. Medicale, 28. pp. 330–332, Nov., 1920.)—The radiochromometer of Benoît and others of a similar nature are in principle based upon the fact that the ratio between the thickness of aluminium and that of silver having the same apparent absorption, increases with the mean penetration of the radiations. This penetration is expressed by the thickness in mm. (degrees Benoît) of a layer of Al such that the fraction of the radiation which traverses it produces upon the photographic plate or fluorescent screen an action equivalent to that of the fraction transmitted through a layer of silver 0·11 mm. thick. The Benoît degrees of hardness obtained with ionised gas bulbs vary from 3 to 7·5. A surprising fact in connection with Coolidge tubes, in which the mean tension reaches 95,000 volts, in place of 60,000 to 70,000 as employed in other bulbs, is that a degree Benoît superior to 7 is never reached. On the contrary, an elevation of the voltage above 70,000 lowers the degree Benoît. The principle of the Benoît radiochromometer is therefore not valid for the whole range of X-rays, the ratio of the equivalence thickness of Al thickness of Ag passing a max. and then decreasing with increase of penetration of rays. A. E. G.

731. *Recent Developments in X-ray Technology.* **R. Knox.** (Röntgen Soc., J. 17. pp. 5–20, Jan., 1921. Presidential Address.)—A brief review is given of X-ray developments, particular reference being made to the work of Ledoux-Lebard. Reference is made to the lack of unanimity between those concerned in the design, manufacture, and operation of X-ray apparatus, and the sharp line of demarcation between apparatus for radiographic and therapeutic purposes.

Radiographic Requirements.—Single-impulse apparatus is dealt with, and it is shown that such impulses are by suitable optical methods, capable of being analysed into a series of diminishing waves. The author, and likewise Coolidge, has greater preference for transformer apparatus than for coil apparatus. As regards the tube, the author considers the Lilienfeld tube to have advantages over that of Coolidge. Experimental data are given illustrating the greater penetration of the gas tube as compared with the Coolidge tube, but there is no difference in sharpness of the radiograms. Reference is made to a German "boiling tube," which is stated to be superior to the Coolidge tube. The author then describes his practical experience with the Lilienfeld tube, which works equally well from a coil or a transformer, and has a constant hardness after many hours' working. He mentions the lack in this country of any tube comparable to that of Coolidge or of Lilienfeld, and suggests their manufacture in Britain, with resultant improvement in high-tension current production, of the X-ray tube and its control, and in photographic emulsions. The hot-kathode tube with a high-tension transformer is stated by the author to be the ideal combination.

Radiotherapeutic Requirements.—In radiotherapeutics the most penetrating ray available is the radium γ-ray, X-ray apparatus of the greatest power only giving in comparison wave-lengths one-third as long. The effect of rays on biological tissue is to stimulate the normal tissues so that these can encapsulate and perhaps eventually kill the more vigorous parasitic cells of new growths. The dose must be sufficient to damage the new growth cells, whilst stimulating the normal cells. Physical data show that radium γ-rays are absorbed by the tissue and give rise to a secondary radiation which induces chemical reactions. The margin of safety dividing beneficial and injurious actions may be very small. The action of radiation is both on the blood stream and on the other tissues. The treatment of cancer is dealt with, and also the error of drawing conclusions from post-mortem findings. It is suggested that a larger wave range should be available to the radiologist, and much research work is desirable regarding the action of radiations on human tissues.

The measurement of radiation is discussed. For this the barium platinocyanide pastille is most useful, but is liable to error. German apparatus is stated to produce radiations equal to radium γ-rays, and in conversation with Coolidge the author was informed that X-ray apparatus is possible, having wave-lengths equivalent to that of radium, with the use of 1 to 3 million volts, so obviating the difficulties of radium supply. Details of practical measurements of dosage are then given, and finally present methods are discussed and the need for future physical, technical, medical, and photographic sub-committees in a Radiographic Institute on the lines of the Mackenzie Davidson Memorial Fund. Special reference is made to recent Russian advances in this connection. B. J. L.

732. *Determination of Time of Exposure in Radiography.* **G. Contremoulins** and **E. Puthomme.** (Comptes Rendus, 171. pp. 1383–1384, Dec. 27, 1920.)—To obtain comparable X-ray plates it is necessary to state the relation of the time of exposure. The authors give the formula: $t = \mathrm{E}^2 e^{-l(1-\mathrm{K})}$, where E is the thickness of the subject with normal incidence, l the variable spark length in cm., and K a constant for the installation. On development of the plates in which the duration is defined by the above equation, differences occur according to the difference of l and a further formula $m^2 = e^{a(1-\mathrm{K}')}$ is given, where m is the "equivalent thickness" and K′ depends on the developer. Actual values of l and t are given for exposures, on the human thorax, with with an 8-mm. tube. B. J. L.

733. *"Thermion" Röntgen Device for Actuation of Gas-containing Röntgen-ray Tubes.* (Elektrot. u. Maschinenbau, 38. pp. 311–312, July 11, 1920.)—A particular arrangement of circuits for X-ray work is described and illustrated. This is actuated from a.c. mains *via* a transformer and a hot-filament valve rectifier feeding the X-ray tube. The arrangement is described in detail, and the rectifying effect is illustrated by voltage curves. B. J. L.

734. *Some Problems in the Biological Action of Radiations.* **S. Russ.** (Röntgen Soc., J. 16. pp. 134–139; Disc., 139–141, Oct., 1920.)—A table is given illustrating the general effects of heat, light, ultra-violet rays, X-rays, and γ-rays on chemical reaction, photographic reaction, electronic emission, biological reaction and physiological reaction The dependence of tissues, in their reaction to X-rays, upon the particular prevailing condition of physiological mitosis is then pointed out. The disagreement of experiments *in vitro* and *in vivo* is illustrated by experiments regarding the decrease of lymphocites in the blood of the rat when exposed to X-rays, whilst on the other hand consistent results may be obtained in similar experiments regarding the effect of radium β-rays on rat sarcomata. The author suggests an explanation of these differences on the ground that the seat of the reaction is extra-cellular in the first case and intra-cellular in the second case—a suggestion, however, which the author does not wish to press. Selective and differential responses to the action of rays upon the same histological tissues are possibly due to a different stage in the life cycle.

The final section is a very suggestive discussion of the relation between degree of biological action and the absorbed energy of the radiation, which bears no simple relation and would appear to be due to the energy liberated from the tissues by the radiations, and it is particularly pointed out that those rays which give rise to the most striking biological reactions also cause marked electronic emission. B. J. L.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

735. *Isotopes of Chlorine; Spectroscopic Evidence of their Existence.* **A. Kratzer.** (Zeits. f. Physik, 3. 6. pp. 460–465, 1920.)—Theory shows that the isotopes of chlorine should furnish spectroscopic evidence of their existence. This is found in the rotation spectrum of HCl. For the band at 1·76 μ, the theory given shows that the lines should occur in pairs with a constant wave-length difference of 13·54 Å. units, and the long-wave components should have an intensity about one-third of that of the short-wave components. Imes' measurements of this band show that on the long-wave side of each principal line there is a weak component, and measurements of the separation of the two components give the constant value 14 ± 1 Å. units. The measurements were made from the curves given by Imes, and the remarkable agreement is sufficient to justify the assumption that the theory given is substantially correct. A. W.

736. *Atomic Structure and Chemical Properties.* **E. Kohlweiler.** (Phys. Zeits. 21. pp. 543–549, Oct. 15, 1920.)—The author's theory of element evolution, structure of the atomic nucleus and isotopy, in which the chemical character of an element is essentially conditioned by the atomic nucleus, is opposed to the prevailing views of physicists. He assumes that after formation of a nucleus centre, consisting of a helium nucleus or of two hydrogen nuclei for maximum valency elements, the positive charges of the helium nucleus which are not compensated by nuclear electrons, are in groups of 8 units and the non-group charges, which increase from 0 for noble gases to 8 for the three transition elements and to 14 for the halogens of groups 0–VIII in the periodic system, determine the group character of the elements. The smaller or greater number of groups of 8 positive units condition the phenomena of analogous and isotopic elements. The nucleus is held to be of primary importance for chemical characteristics, while the external electrons only play a secondary part. The number of these electrons corresponds with the number of ungrouped positive quanta of the nucleus, and thereby to the maximum valency of the element. These electrons are mainly concerned with the changing valency of the atom. The present paper is an extension of the author's previous work [see Abs. 1217 (1919)], in order to provide further evidence for the important part played by the atomic nucleus in determining chemical nature. The facts that optical spectra show no additive properties but feebly periodic characteristics; the connection between valency and onisation, ithermochemical processes, radio-active phenomena, paramagnetism; and the optical displacement hypothesis of Kossel and Sommerfeld, whereby the spark spectrum of an element should be identical with the arc spectrum of the preceding element of the same type;—all these are discussed at length and shown to support the author's hypothesis. H. H. Ho.

737. *New Periodic Relation between the Atomic Weights of the Chemical Elements.* III. *Resonance Theory of Chemical Compounds.* **K. Fehrle.** (Phys. Zeits. 21. pp. 552–554, Oct. 15, 1920.)—From his former assumption of the atom as units on the surface of a sphere [*ibid.*, p. 163, 1920], the author derives an expression for the angular velocity of rotation of any atom, and finds that the vibration numbers of the inert gases bear to one another the ratios, $\frac{1}{2}:\frac{1}{3}:\frac{1}{4}:\frac{1}{5}:\frac{1}{6}:\frac{1}{7}$, so that the resonance of these elements cannot be improved by combination with other elements. The latter, by combination, have their vibration component altered so that the vibration ratio is brought into line with those of the inert gases nearest to the two elements combining. Thus, if lithium unites with fluorine, the components attain the vibration ratio, 3 : 2. Various relations between the vibration frequencies of atoms and molecules are considered.

T. H. P.

738. *Radiation as a Factor in Chemical Action.* **I. Langmuir.** (Am. Chem. Soc., J. 42. pp. 2190–2205, Nov., 1920.)—In order to account for the close similarity between the Arrhenius equation for the velocity of chemical reactions and the Wien radiation law—which states that the natural logarithm of the intensity of any monochromatic black-body radiation is a linear function of the reciprocal of the absolute temperature—and also to explain the fact that the velocities of unimolecular reactions cannot be dependent on the number of collisions between molecules, it has been suggested by Trautz, Lewis, Perrin, and others, that molecules are able to take part in chemical reactions only after they have become activated and that this activation is brought about by the absorption of a nearly monochromatic radiation. There seems to be ample evidence supporting the activation of the molecules, but the radiation hypothesis does not appear to rest on a firm foundation.

There are two decisive tests of the validity of the radiation hypothesis: (1) The reacting substance must absorb radiation of the frequency required to produce activation, and there must therefore be an absorption band which includes this frequency; (2) the total amount of radiant energy absorbed must be sufficient to supply the known heat of activation to the molecules which react.

Examination of the available data indicates that there is little evidence that absorption bands occur which include the frequency corresponding with the activation. Thus, in the dissociations of phosphine, nitrous oxide, nitric oxide, phosgene, and phosphorus and arsenic vapours, the activation frequencies lie within the range of the visible spectrum, but the fact that the gases are all colourless proves the absence of absorption bands from this region.

Analysis of the experimental data on the velocity of dissociation of phosphine shows that the energy actually required for activation in 1 cm.^{3} at 948° K. is 4×10^{10} times the amount that can be supplied by radiation from 1 cm.^{2} of surface at 948° K. Furthermore, when the intensity of the radiation is increased enormously (as by using daylight), the reaction velocity exhibits no corresponding increase.

The results obtained with nitrogen peroxide, hydrogen, and iodine vapour show that the thermal conductivity of dissociating gases is many times greater than that of similar gases which do not dissociate. The increase in the loss of heat from small wires, due to dissociation of the surrounding gas, is often more than ten times the total energy radiated from the wire, whereas the radiation hypothesis indicates that the dissociation entails absorption of radiation and could produce only a decrease in the amount of heat lost by the wire. The radiation hypothesis is thus precluded by the results obtained.

The similarity between the Arrhenius and Wien equations results from the fact that both reaction velocity and radiation are fundamentally dependent on phenomena involving probability; both equations may, indeed, be deduced from one and the same statistical law. It is further found that, unless the law of the conservation of energy has also only a statistical significance, the activation energy must be derived from internal energy of the molecules which exists at the zero of absolute temperature. The very fundamental difficulties involved in this conclusion are of the same nature as those encountered in the theory of the photoelectric effect, thermionic emission, and other phenomena involving quantum relations.

T. H. P.

739. *A Method for the Quantitative Study of Chemical Reactions with an Accuracy Expressed in Masses of* 10^{-14} *gm.* **D. K. Konstantinowsky.** (Phys. Zeits. 21. pp. 689–690; Disc., 690, Dec. 1 and 15, 1920.)—The micro-balances of Nernst, which are exact up to 1 % with 10^{-7} gm., of Ramsay, which reach $2 \cdot 5 \times 10^{-8}$ gm., and of Petterssen, which attain $2 \cdot 5 \times 10^{-10}$ gm., are first mentioned in this connection. A comparison is then made with the sensitiveness obtained by Ehrenhaft's experimental condenser method, which reaches an accuracy of up to 10^{15} gm. Sufficient explanation is now given of the Ehrenhaft method to show its utility in the quantitative study of chemical reactions; *e.g.*, the absorption and adsorption of gases, such as chlorine by small particles of Se, Hg, and Sb. Application to the Brownian movement has been made, and the method is held to be especially suitable for research in colloidal chemistry.

H. H. Ho.

740. *Electric Conductivity and Constitution of Liquid Metals and Alloys.* **F. Skaupy.** (Phys. Zeits. 21. pp. 597–601, Nov. 1 and 15, 1920.—Paper read before the 86. Naturforscherversamml., Nauheim, Sept., 1920.)—Whilst homogeneous solid solutions (mixed crystals) of alloys have a much smaller electric conductivity than the main metal mixed with a little of the second metal, the conductivity of liquid mercury is increased by alloying it with small proportions of Pb, Zn, Cd. Yet there need not be a difference in principle between liquid and solid alloys. For the alkali amalgams are poorer conductors than Hg, and this diminution in conductance is accompanied (Fenninger, dissertation, Freiburg, 1914) by a considerable increase in internal friction, whilst the better conducting alloys show only a small increase in friction. As regards liquid metals and solutions of electrolytes the author suggests the following analogies: (1) The electric conductivity of the pure solvent and of the diluted solution must be a function of the electron concentration and of the internal friction; (2) diluted solutions of metals must show a higher electron concentration than the solvent in cases when the solute is dissociated by splitting off electrons; (3) since solvent and solute contain a common ion, *i.e.*, the electron, there must be chemical equilibrium between the two, and (4) the change of the electron concentration of the pure solvent with temperature and pressure must depend upon this equilibrium; (5) changes in concentration must occur when the electric current is passed through liquid alloys. These conclusions are mathematically discussed. One of the deductions is that the degrees of dissociation of most metals do not differ very much. If H be the ratio of the degree of dissociation of a solute to that of the pure solvent, so that $H_\infty = \gamma_\infty / \epsilon$, then (according to

Fenninger) the $H_\infty \times 10^2$ are: Li 8·5, K 14, Cs 26·5, Ba 29, Tl 4·1, Zn 10·5, Cd 7·2, Bi 5·5, Sn 9·4, Au 14·9. For Hg, $\epsilon = 0 \cdot 04$ (*i.e.*, 100 atoms of Hg possess 4 free electrons) against 0·002 by other methods. [In this estimate the degree of dissociation of caesium, which has the highest H_∞ of all metals, in Hg is taken as unit.] There may be double atoms in zinc amalgams. As regards (5) the alkali metal really travels to the anode in amalgams according to Lewis, Adams, and Lanman [Abs. 265 (1916)], though the rates are very small. From quantitative considerations the author now suggests that the positive ion goes to the kathode, while the bulk of the liquid keeps its position, but a small portion, and with it the alkali metal, travels to the anode. H. B.

741. *Origin of Chemical Energy.* **M. Polanyi.** (Zeits. f. Physik, 3. 1. pp. 31–35, 1920.)—Having shown [Abs. 179 (1921)] that chemical reactions are not mechanical in nature, *i.e.*, that the work done against the forces of affinity is not taken from the kinetic energy of the atoms participating in the reaction, but is, to put it briefly, "taken from the ether," the author explains how this may be understood. When N_2O_4 is dissociated into $2NO_2$, energy can be taken from the ether, so far as we know, only in one way—by absorption of heat radiation. The non-mechanical source of energy would hence be simply radiated heat, and we should have to trace back all chemical processes to photochemical effects of heat radiation, as has frequently been attempted during the last two decades. The object of the author is to prove that this is inadmissible, and that energy must be taken up from space in some unknown way, as to which he makes suggestions. The rate of dissociation of N_2O_4, he shows, should theoretically be slow, whilst it is known to be comparable with the velocity of sound. The suggestion is that, in the emission of radiation, a quantum jump through which an electron passes is coupled with a quantum jump of the ether; the first jump takes place under loss of energy, for which the second jump compensates. Similarly quantum jumps of two material systems are coupled with one another. In the case of photochemical reactions light is primarily swallowed by an electron jump, which has in itself nothing to do with the chemical reaction; the reaction only sets in when the electron, dropping back, couples itself with an atomic jump. That would make it intelligible why reverse photochemical reactions are not luminescent. H. B.

742. *Metallographic Investigation of the System, Tungsten-Lead.* **S. Inouye.** (Kyoto Coll. Sci., Mem. 4. pp. 43–46, Oct., 1919.)—At temperatures as high as 1300° lead dissolves up to 30 % of tungsten; the tungsten separates first from the molten mass, the residue solidifying as a eutectic, which consists practically solely of lead. No signs were obtained of the formation of a compound between the two metals. T. H. P.

743. *Metallographic Investigation of the System, Bismuth-Selenium.* **N. Tomoshige.** (Kyoto Coll. Sci., Mem. 4. pp. 55–60, Oct., 1919.)—This system forms two compounds: BiSe, decomposing at 602°, and Bi_2S_3, melting at 688°. The former compound, BiSe, occurs in two allotropic forms, the transformation point being about 422°. With 51–90 % of selenium, the Se does not mix with the compound, Bi_2Se_3, in the fusion, so that two liquid layers are formed. One eutectic, melting at 267°, consists practically only of bismuth, and the other, at 161°, of Bi_2Se_3 and selenium. T. H. P.

744. *The Thermoelectric Determination of Transition Points.* **A. Smits and J. Spuyman.** (K. Akad. Amsterdam, Proc. 23. 5. pp. 687-690, 1921.)—Measurements are made of the transition point of tetragonal into rhombic tin by means of a thermo-element, in which the metal under investigation forms one of the elements of the thermo-couple, with iron as the second metal. The transition point of tin appears very clearly at 200·2° C., which agrees with results given by dilatometric measurements. When a temperature lying above the melting-point of tin was rapidly lowered, the transformation failed to appear, and the metastable prolongation of the upper branch of the curve could be followed for some distance. With a couple of tin–copper, the transition point appears at 200·5° C., but the break in the e.m.f. curve is in this case less abrupt. J. N. P.

745. *Stable and Unstable Colloids.* **F. Schoucroun.** (J. de Physique et le Radium, 1. pp. 65–76, Sept., 1920.)—In order to ascertain if unstable colloids belong to those substances the electrification of which may be made to approach zero but not to change its sign, the author has investigated the electrification of gamboge, mastic, ferric hydroxide, and arsenic sulphide. The procedure employed was virtually Perrin's electric osmosis method, a diaphragm of the substance being immersed in a certain liquid and a p.d. established between its extremities; the liquid undergoes displacement in a definite sense, being transported by the ions of contrary sign to those charging the diaphragm, which is kept motionless. With these unstable colloids it is found possible, by addition of increased proportions of suitable electrolytes, to diminish the charge of the colloidal particles, but reversal of the sign of this charge cannot be effected, no matter what the concentration of the H^+ or OH^- ions used.

It is found also that gelatine "micelles" are capable, in an electric field, of functioning as motor granules, transporting the liquid with them, and use is being made of this property for investigating, by the electric osmosis method, stable colloids from which no diaphragm can be constructed. T. H. P.

746. *Planck's Theory of Dilute Solutions.* **P. Boedke.** (Phys. Zeits. 21. pp. 551–552, Oct. 15, 1920.)—Planck's theory [Abs. 773 (1920)] is extended so as to cover concentrated solutions and it is shown that retention of terms of the second order in respect of concentrations in the expression for the potential is not sufficient for a more general quantitative formulation of the phenomena encountered in concentrated solutions. Investigations on the molecular condition of binary mixtures and on further systems with closed saturation curves are necessary for the further development of the theory. T. H. P.

747. *Molecular State of Water-Vapour.* **J. Kendall.** (Am. Chem. Soc., J. 42. pp. 2477–2482, Dec., 1920.)—The discordant conclusions of Bose [Abs. 2069 (1908)] and of Oddo [Abs. 460 (1916)] regarding the molecular state of water-vapour are discussed. It is shown that the evidence for the existence of the equilibrium, $H_2O \rightleftarrows H^+ + OH^-$, at low temperatures and of the equilibrium, $2H_2O \rightleftarrows (H_2O)_2$, at higher temperatures is in each case quite insufficient; that the abnormalities in the vapour densities of normal substances at their boiling-points are similar to that of water-vapour at 100°, and that such abnormalities practically vanish when the corrections for deviations from the perfect gas laws are applied.

An "equation of state" correction is similarly necessary in gas reactions at high pressures, in calculations on dissociation in the vapour state, and in Dumas or Victor Meyer vapour-density determinations. T. H. P.

748. *On the Work of Ionisation and of Dissociation of Hydrogen; New Determinations.* **T. Krüger.** (Ann. d. Physik, 64. 3. pp. 288–304, Feb. 9, 1921.)—Bohr's atomic model is first discussed [see Abs. 1042 and 1437 (1915)], since this conception has led to a relationship between the energy transference of impacting electrons and the optical series. According to the Bohr-Debye conception, the hydrogen molecule consists of two positive nuclei about whose connecting line as axis the two electrons circulate in a common quantum orbit. When an electron is removed, the residue, according to the theory, becomes unstable, and positive molecule ions not being possible, a further disintegration into an atom and a positive atomic ion must take place. The separation of an electron from a hydrogen molecule, therefore, not only involves the work of ionisation, but also that of dissociation. According to Bohr this amounts to 60,000 gm. cals., corresponding to 2·6 volts. The model, however, is unfortunately not in complete agreement with the facts, since Thomson has observed positive molecule ions with canal rays, while the calculated value for the work of dissociation does not correspond with that by experiment. Nernst gave 100,000 gm. cals. = 4·3 volts as the most probable value. Finally H_2 should be paramagnetic from the model, while it is diamagnetic in reality. The present paper contains a new set of experimental determinations of the work of ionisation and dissociation of hydrogen, and the arrangements employed receive most detailed description. The first strong ionisation in hydrogen is found to take place at 17·1 ± 0·25 volts, the second at 30·4 ± 0·5 volts. The former value is explained by the dissociation of the molecule and ionisation of an atom, the latter by the dissociation of the molecule and ionisation of both atoms. On this assumption, the work of dissociation is estimated from the above two values at 3·5 ± 0·3 volts, corresponding to 81,300 gm. cals. ± 5700 gm. cals. Values of 11 and 13·5 volts, found by other means, were confirmed within an error limit of 0·7 volt, weak ionisation being found to ensue at 11 volts and radiation at 13·6 volts. The light-effect at 13·5 volts was ascribed to the dissociation of the molecule with simultaneous resonance radiation of an atom, while the ionisation at 11 volts was assumed to be the energy of formation of the hydrogen molecule ion. H. H. Ho.

749. *Transport Number of Chromic Ions in the Violet Chloride.* **K. Hopfgartner.** (Monatsh. d. Chemie, 40. pp. 259–269, June 28, 1919.)—By the method of Hittorf the author determines the transport number of the chromic ion in hydrochloric acid solutions of the violet chromic chloride at the equivalent concentrations 1·00, 0·32, 0·075. The numbers found are 0·318, 0·357, 0·414, which suggest 0·446 for zero concentration. From these data and by extrapolation the mobility of the violet chromic ion is estimated at 53, 49·5, or 46·3, the first figure being probably too high. The chromic ion is probably surrounded by a large envelope of water; but the estimates of the numbers of molecules in the envelope vary considerably, between 32 and 51. H. B.

750. *Cause of the Low Conductivity of Non-Aqueous Solutions.* **R. Beutner.** (Zeits. Elektrochem. 25. pp. 97–100, April 1, 1919.)—

Non-electrolytic dissociation cannot directly be determined, nor be deduced on purely theoretical grounds. It is believed to exist because (1) non-aqueous solutions containing both acid and base have a very much greater conductivity than solutions containing acid or base alone; (2) the conductivity of non-aqueous solutions changes continuously when we change the basic concentration keeping the acidity constant, or *vice versa*; (3) the molecular conductivity decreases with increasing solution. A high conductivity is due to the presence of a salt; in most non-aqueous solutions the equilibrium exists in salt $\rightleftarrows$ base and acid, so that all three coexist. The non-electrolytic dissociation opposes the electrolytic. The experiments were made with salicylic acid and dimethyltoluidine or nitrobenzene. H. B.

751. *Electromotive Activity of Carbon Monoxide.* II. **K. A. Hofmann and B. Wurthmann.** (Deutsch. Chem. Ges., Ber. 52. [B] pp. 1185–1194, June 14, 1919.)—When carbon monoxide is oxidised at a copper electrode wetted with caustic alkali, its oxidation energy is largely converted into electric energy at ordinary temperature [Abs. 935 (1920)]. CO is more active at a copper electrode than at a hydrogen electrode. At the copper electrode a primary oxide Cu_2O_3, aq. (or possibly CuO_2, aq.) is formed in the presence of alkali, as the author had shown; this agrees with a previous observation by J. Meyer. If the hydrogen potential against the reversible oxygen electrode be 1·237 volts, that of CO is 1·32. According to Auerbach the potential should, however, be higher, namely 1·68 volts. Without discussing this objection the authors claim for the present to have established that CO in presence of Cu and alkali takes a higher potential than hydrogen takes on platinum. H. B.

752. *Depolarisers of the Becquerel Effect.* **A. v. Samsonow.** (Zeits. wiss. Phot. 18. pp. 141–176, Dec., 1918.)—The Becquerel effect (current generation by illumination of one of two electrodes immersed in an electrolyte) is probably general, but is mostly observed with metals covered with oxide or halogen compounds or with the noble metals in sensitive electrolytes. The author, working with oxidised copper electrodes in sodium salt solutions, finds that the iodate and bromate give much higher potentials than the chlorate and sulphate. Oxidising and depolarising agents counteract the polarisation. Various depolarisers are studied, photographic developers, glycine, ferrous sulphate and oxalate, sodium sulphite, phosphite and arsenite and *p*-aminophenol. No theory can be advanced so far, only a working hypothesis. The author develops Goldmann's electronic theory which goes back to Luggin, but he refrains with Goldmann from the consideration of the thermodynamical changes of the potential by light. H. B.

753. *Discharge Electrolysis; Electric Colloid Synthesis.* **V. Kohlschütter.** (Zeits. Elektrochem. 25. pp. 309–323, Oct. 1, 1919.)—The author regarded colloid-preparation after Bredig and Svedberg as due to a condensation of vapours; Benedicks considered that there was merely a thermo-mechanical disintegration of fused beads. In what he now calls discharge-electrolysis the author electrolyses pure water between parallel electrodes of copper by currents of at least 100 volts pressure. The simple arc discharge disintegrates only the kathode into coarse metallic particles. When capacity is added to the circuit, the process shifts more or less over the anode, and colloidal copper oxide is produced; this process may be worked with both direct and alternating current. The smaller the current intensity, the finer the colloidal particles, which can easily be separated from the coarser metallic ones. The anode apparently becomes covered with a disperse oxide layer which the discharge disintegrates. H. B.

754. *Electrolysis of Sodium Nitrite Solutions, using a Silver Anode.* **F. H. Jeffery.** (Faraday Soc., Trans. 15. pp. 16–20, June, 1920.)—In order to study the compound between sodium nitrite and silver nitrite and the complex anions of Pick and of Oswald, the author electrolysed solutions of sodium nitrite of various concentrations with a silver anode and a Pt kathode, the latter placed in a porous pot, at ordinary temperature; all the substances were pure. No silver was deposited, and none observed in the katholyte. The anode became coated with a coherent film, which for some hours did not diminish the current, but finally stopped it. This film is practically $AgNO_2$, containing an excess of finely-divided silver, due to disintegration of the anode. That the presence of NO_3 ions near the anode did not raise the concentration of the silver ions there was proved by potentiometer tests in solutions to which $NaNO_3$ was added. Bright yellow crystals of $NaAg(NO_2)_2$ were obtained by long-continued electrolysis; when the isothermal evaporation is further prolonged, crystals of mixtures of this salt with $NaNO_2$ are produced, the percentage of the sodium nitrite increasing with time. H. B.

755. *Qualitative and Quantitative Determination of Nickel and Cobalt.* **M. Matsui** and **T. Nakazawa.** (Kyoto Coll. Sci., Mem. 4. pp. 265–271, Sept., 1920.)—Methods for the detection of nickel and cobalt by means of dimethylglyoxime are described, and it is shown that these two metals may be estimated when present either separately or together by electrolysis of their dimethylglyoxime compounds. T. H. P.

756. *New and Rapid Apparatus for Electrochemical Analyses.* **J. T. King.** (Univ. of Toronto, Eng. Research School Bull. No. 1. pp. 69–81, 1919.)—In order to attain improved agitation of the electrolyte used in electrochemical analysis and thus accelerate the deposition of the metal the author employs the device of rotating the containing beaker. The complete design of the apparatus, other principal features in which are the system of wiring and the form of the electrode holders, is described in detail; the lowering of one of the beakers and the consequent removal of one of the cells from the circuit does not interrupt the current in the other cells in use. Test determinations of the proportion of copper in various brasses show that, as regards speed and accuracy, the author's apparatus is quite satisfactory and compares favourably with other forms. T. H. P.